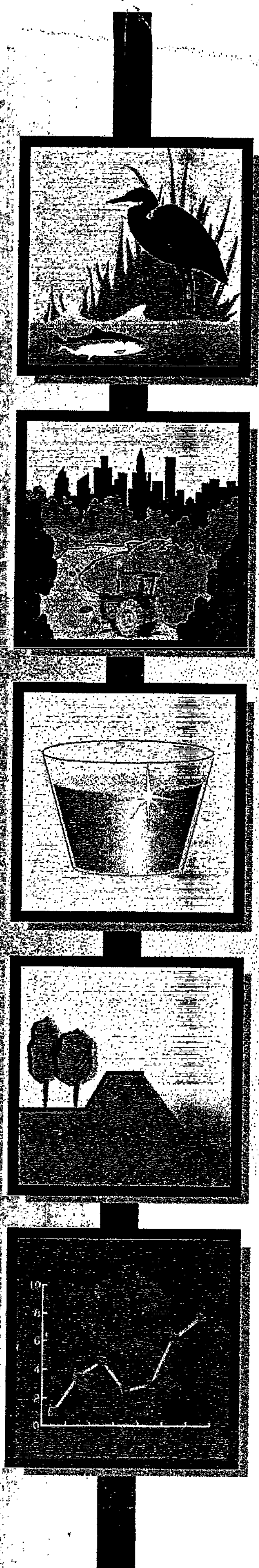

CALFED
BAY-DELTA
PROGRAM

Affected Environment and Environmental Impacts

Flood Control

Draft Technical Report
September 1997

CALFED/711

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1.0 SUMMARY

Flood control resources may be affected, to various degrees, by the CALFED Bay-Delta Program (CALFED) alternatives. This flood control system discussion focuses on the area of the Central Valley that composes the Sacramento-San Joaquin Delta problem area, San Francisco Bay, and the Sacramento River and San Joaquin River regions. The Central Valley Project (CVP) and State Water Project (SWP) service areas outside of the Central Valley do not directly affect flood control resources in the Central Valley. The affected environment discussion focuses on levee integrity and flood management operations. The features of the levee and flood management described in this report include current processes affecting levee stability and structural integrity, operations that govern reservoir and flood management, and the regulatory structure. The role each of these elements has in managing floods in each of the study regions is summarized below.

The levee systems are governed by federal, state, and local agencies. Levee systems are either federal roject levees or local nonproject levees. Federal project levees include those constructed as part of the Sacramento River and San Joaquin River Flood Control Projects. Project levees are maintained to federal standards by the state or by local landowners under state supervision. Nonproject levees are constructed and maintained by local reclamation districts. Federal and state agencies have no jurisdiction over these levees and cannot require that they be maintained. However, disaster claims could be denied if local districts do not follow federal or state requests for upgrade. The levees are managed in conjunction with the management of upstream reservoirs and bypasses.

The reservoir, weir, and bypass systems provide additional flood protection. Reservoirs are operated to maximize water storage when demand for water is high and provide flood protection according to a flood control diagram. The flood control diagram essentially defines the amount of space that should be reserved to store flood waters, based on a number of factors, including basin hydrologic characteristics, level of flood protection required, environmental concerns, and obligations for water conservation. The weir and bypass system diverts and conveys flow from the leveed rivers, increasing the overall capacity of the system.

The flood management system depends on close cooperation and coordination among a variety of agencies at the federal, state, and local levels. Many of the agencies operate under state and federal mandates. Flood management operations are conducted from the State-Federal Flood Operations Center (Center) in Sacramento. A number of agencies, including California State Department of Water Resources (DWR), US Army Corps of Engineers (USACE), US Bureau of Reclamation, and local agencies, coordinate flood management efforts at the Center. These agencies rely on climatic and streamflow data compiled by the National Weather Service and the California Data Exchange Center to forecast and manage floods. During a flood, the Center and the USACE determine the expected inflow to each reservoir and adjust releases to maintain water levels within the guidance of the flood control diagrams. During emergencies, the State Office of Emergency Services and the Federal Emergency Management Agency may provide assistance.

In the Delta Region, facilities used in flood control include the levees and the Delta Cross Channel Control Gates. The Delta levee system initially served to control island flooding during periods of high flow. However, because of land subsidence due to peat oxidation, the levee system is now necessary to prevent inundation during periods of normal flow. The levees often settle under their own weight, and material must be added to the crowns to maintain height. Levees can fail due to several mechanisms, including overtopping, seepage and piping, and instability. Factors affecting levee integrity include erosion, structure encroachment, subsidence, cracks and fissures, and burrows and roots. During periods of high flows on the Sacramento River, the cross channel gates are closed to prevent water spilling from the Sacramento River to the Mokelumne River and flooding leveed and unleveed lands. Alternatively, the gates may be opened when the Mokelumne River stage is greater than the Sacramento River stage, to reduce stages on the north and south forks of the Mokelumne River.

In the Bay Region, no significant facilities or resources are at work to control floods from the Delta. Historically, the bay has not suffered from floods emanating from the Delta. Generally, floods have resulted from local runoff due to intense rainstorms.

Current flood control resources at work in the Sacramento River Region include levees, reservoirs, and weirs and bypasses. Levee protection is provided by the Sacramento River Flood Control Project levees and some nonproject levees. Major reservoirs that provide protection include the CVP, SWP, and locally funded reservoirs. The weir and bypass system diverts water to protect the levee system and to free up flood storage capacity in the reservoirs. The flood control system goes into action days before a flood. Based on weather forecasts, higher than usual releases are made from reservoirs to create additional runoff storage capacity. By storing water in the reservoirs and bypasses, the flood control system can minimize the peak flows that the river and levee system are required to handle.

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In the San Joaquin River Region, levees, reservoirs, and weirs and bypasses also are relied on to provide flood protection. Levee protection is provided by local nonproject levees and the San Joaquin River Project levees. The levee and reservoir system is operated to control floods using the same methods as those used in the Sacramento River Region.

2.0 INTRODUCTION

The purpose of this technical report is to describe the affected environment for flood control resources. In order to accurately describe the affected environment for these resources, the report defines current and historical conditions for flood control operations and levees. The historical conditions are presented to place current conditions in perspective. This report contains the relevant regulatory context, historical flood control efforts, and the existing flood control system for the study area.

The current and historic conditions are described for the Delta Region, Bay Region, Sacramento River Region, San Joaquin River Region, and the State Water Project (SWP) and Central Valley Project (CVP) service areas outside of the Central Valley. The Delta Region consists of the legally defined Delta plus Suisun Bay to the eastern end of Carquinez Strait and Suisun Marsh. Solutions to be considered for CALFED alternatives are addressed in the problem area (the Delta), and more generally in regions upstream and downstream of the Delta. Thus, the level of detail included in this report is highest for the Delta Region.

CALFED has identifiede the Sacramento-San Joaquin Delta (Delta) Region as the primary "problem area." However, flood control systems and conditions in the other regions are also of concern because activities in these regions might affect or be affected by CALFED alternatives. The CALFED study area is illustrated on Figure 1.

Figure 1 - Study Area Map - To be provided by CALFED.

3.0 SOURCES OF INFORMATION

Flood control information for the Delta and the basins that are tributary to the Delta was collected from reports prepared by the California Department of Water Resources (DWR), the Bay-Delta Oversight Council, the U.S. Army Corps of Engineers (USACE), and other public agencies and private firms. Information on the existing Delta flood control system was obtained primarily from the Bay-Delta Oversight (BDOC's) Committee's Briefing Paper on Delta Levee and Channel Management Issues and DWR's 1993 Delta Atlas. Data on the risk of levee failure in the Delta were taken from the USACE 1982 Sacramento/San Joaquin Delta Draft Feasibility Report and EIR/EIS and the 1993 Sacramento River Flood Control System Evaluation.

Other related studies that include information on the Delta flood control system were consulted, including the

Draft EIR/EIS for the North Delta Program (DWR 1990a), Interim South Delta Program (DWR 1996), Delta Levees Investigation (DWR 1982), and the Draft EIR/EIS for the Delta Wetlands Project (Jones & Stokes Associates 1995). A list of references used in preparing this report has been included in the References section (Section 5.0).

Frequently used technical terms in this report are defined in Section 6.0, Glossary.

4.0 ENVIRONMENTAL SETTING

The following sections describe the study area, regulatory context, and common issues for the regions described in this report.

4.1 Study Area

The study area includes the Sacramento-San Joaquin Delta, San Francisco Bay Region, the Sacramento River Region, the San Joaquin River Region, and the CVP and SWP service areas. Alternatives considered by CALFED may affect flood control in these areas.

4.2 Regulatory Context

The flood control systems described in this report are governed by Federal, State, and local agencies. Levee systems are referred to as either Federal project levees or local nonproject levees. The San Joaquin River and Sacramento River Flood Control Projects, built by the USACE and turned over to he state for maintenance, provide flood control for the lower reaches of these rivers and into the Delta. Project levees are associated primarily with conveying flood flows and maintaining the Sacramento Deep Water Ship Channel. The project levees work in conjunction with upstream reservoirs and bypass systems to protect adjacent lands against flooding, and to maintain flow velocities adequate to carry out sediments that might impede navigation. Project levees within the Delta are maintained to Federal standards by the State or by local landowners under State supervision.

Nonproject levees are levees constructed and maintained by local reclamation districts. Nonproject levees constitute about 65 percent of levees in the Delta flood control system (DWR 1996). Federal and State agencies have no jurisdiction over nonproject levees and cannot require that they be maintained. However, future disaster claims could be denied if local reclamation districts do not follow Federal and State requests or recommendations to upgrade or maintain levees. Maintaining nonproject levees is largely financed by landowners, and the costs are shared with the State. Nonproject levees are often maintained to widely ranging and less stringent standards than those applied to project levees.

If local reclamation districts are interested in maintenance cost sharing and disaster reimbursement, then nonproject levees are maintained, repaired, and upgraded according to the State's Flood Hazard Mitigation Plan (HMP) for the Delta. Upgrades and repairs are inspected by DWR, and the State Reclamation Board certifies those levees meeting HMP criteria. Certification qualifies these reclamation districts for maintenance cost reimbursement under the Delta Flood Protection Act of 1988 (California Water Code §§12310-12316; 12980-12993).

Since 1947, DWR has inspected and reported on the status and maintenance of flood control levees, channels, and other works operated under cooperative arrangements between Federal, State, and local public entities. This work is part of the process of assurances given by the State to the Federal government. These assurances state that certain flood control facilities constructed by the USACE for local flood protection shall be continuously maintained and operated as necessary to obtain the maximum benefits, as stated in 33 Code of Federal Regulations (C.F.R.) Part 208. DWR, under the authority of Water Code §§ 8360, 8370, and 8371, inspects the maintenance of the Sacramento River Flood Control Project (SRFCP) levees, as performed by the responsible agencies, and regularly reports to the USACE the status of levee maintenance accomplished under the provisions of 33 C.F.R. 208.10. In addition to State inspections, the USACE also performs its own "spot" inspections each year as part of the continuing Federal interest (DWR 1996b). These inspections at the State and Federal levels indicate the ongoing government interest in the importance of levee system maintenance.

Table 1 provides an overview of statutes and regulations that have affected the levee system.

4.3 Flood Management Operations

Flood management operations are common to all study areas.

Flood management is a complex process that depends on close cooperation and coordination among a variety of local, State, and Federal agencies. Many of the agencies, including the DWR and the USACE, operate under mandates founded in State and Federal legislation. A detailed discussion of the complexities of cooperative efforts and legislative mandates is beyond the scope of this report.

The following discussion of flood management operations broadly describes flood management and establishes the affected environment for analyzing the programmatic alternatives.

Flood management operations in the study area are coordinated by an integrated team of representatives from Federal, State, and local agencies. Flood management operations are conducted from the State-Federal Flood Operations Center in Sacramento. During the flood season, a number of public agencies combine their efforts to provide high water warnings and to coordinate flood activities (Figure 2).

DWR and the National Weather Service (NWS) provide official forecasts for the center and cooperating agencies. The California Data Exchange Center

Table 1. Federal and State Statutes, Orders, and Regulations Affecting Flood Control

Date	Statute/Order/Regulation	Federal/State	Provisions Affecting Flood Control
1850	Federal Swamp and Overflow Act	Federal	Provided for the title of wetlands to be transferred from the Federal Government to the States.
1861	Reclamation District Act	State	Allowed drainage of Delta lands and construction of sturdier levees.
1902	Federal Reclamation Act	Federal	Allowed the development of irrigated lands in the western United States.
1911	Reclamation Board	State	Created by the California Legislature to implement a comprehensive flood control plan for the Sacramento and San Joaquin Rivers.
1917	Flood Control Act	Federal	Authorized the Sacramento River Flood Control Project consisting of a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, and overbank floodway areas. Operation and maintenance is the responsibility of the State of California.
1930	State Water Plan	State	Plans transfer of northern California water throughout the Central Valley (becomes CVP).
1933	Central Valley Project Act	Federal	Provided for the construction, operation, and maintenance of a system of works, comprising essentially Shasta Dam and Reservoir, Contra Costa Canal, Delta Cross Channel, Delta-Mendota Canal, Friant Dam and Reservoir, Madera Canal, Friant-Kern Canal, facilities for generation and transmission of electric energy, and such other units as may be from time to time added...."
1948	House Resolution 618, 80th Congress, 2nd Session	Federal	The Department of the Interior was authorized to investigate the feasibility and justify the means for conservation, maintenance, and use of the fresh waters of the Sacramento and San Joaquin Rivers.
1948	Senate Committee on Public Works	Federal	Board of Engineers for Rivers and Harbors was directed to review reports on the Sacramento River for navigation and flood control with a view to determining if it was advisable to modify existing projects in any way to reduce the tidal prism to a minimum.
1950	Section 205 of the Flood Control Act	Federal	The Secretary of the Army was authorized and directed to prepare preliminary examinations and surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects in the Sacramento and San Joaquin River Delta areas.

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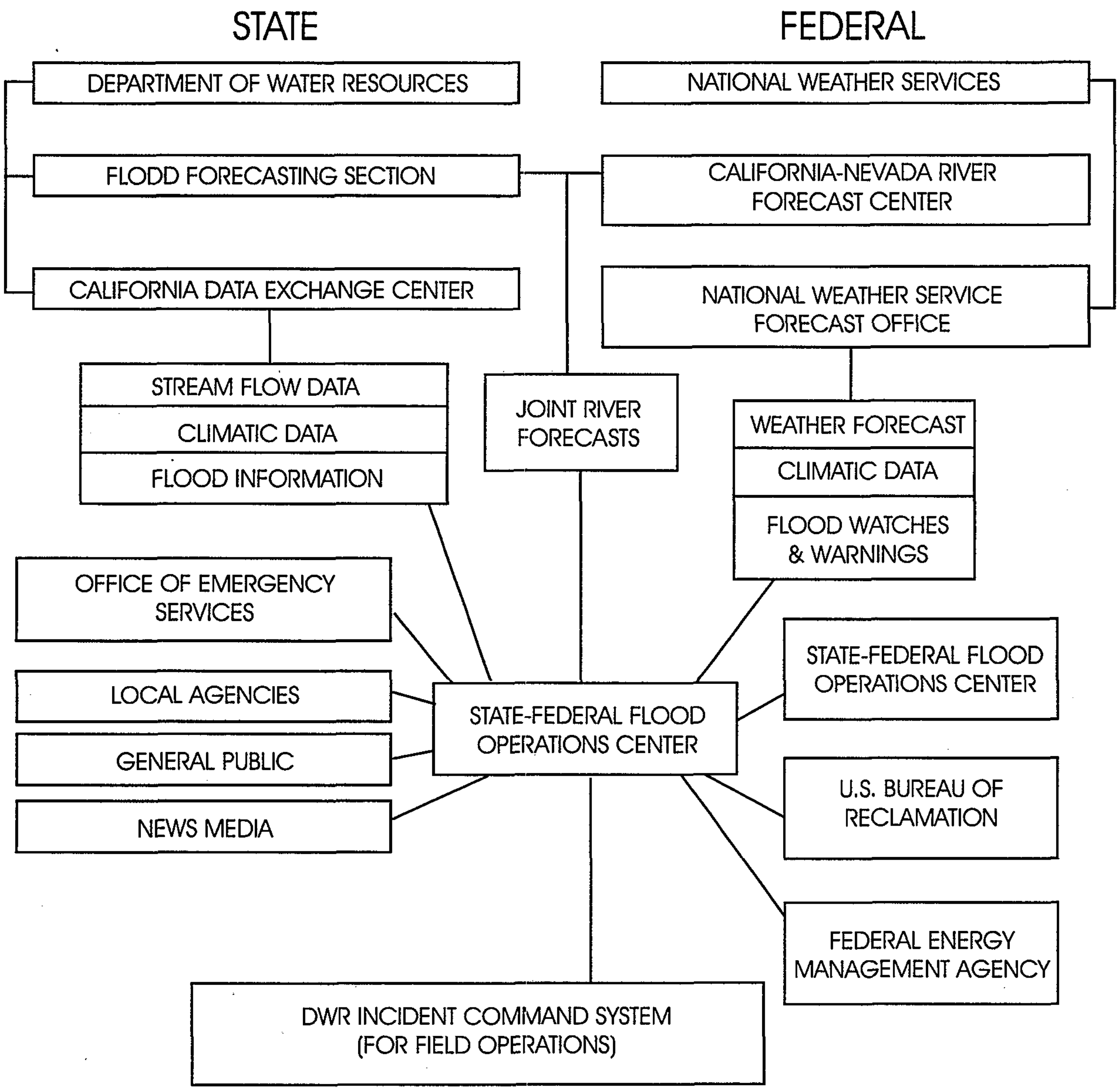
Table 1. Federal and State Statutes, Orders, and Regulations Affecting Flood Control (continued)

Date	Statute/Order/Regulation	Federal/State	Provisions Affecting Flood ControL
1960	State Water Resources Development Bond Act	State	Authorized the sale of $1.75 million of bonds to assist in financing initial facilities of the SWP. Included provisions for master levees, control structures, channel improvements, and appurtenant facilities in the Delta for water conservation, water supply, transfer of water , flood and salinity control, and related functions.
1973	Delta Levee Maintenance Subvention Program	State	Required DWR to develop criteria for (Way Bill) (California Water CodeThe maintenance and improvement based on qualifying plans. Requires DWR to annually inspect planned improvementof nonproject Delta levees. Establishes method for reimbursing some of local agency costs of levee maintenance or improvement based on qualifying plans. Requires DWR to annually inspect planned improvement and maintenance work, and to report inspections to the Reclamation Board for decision regarding cost-sharing certification. Allows advances from DWR to local agencies for such work, and allows DWR to establish and conduct planned routine maintenance in "maintenance areas." Required applicants to first file for Federal disaster assistance whenever eligible.
1976	California Water Code Sections 12225, 12226 and 12227	State	Section 12225 approved the levee improvement (Nejedly-Mobley Delta Levees Act) plan set forth in Bulletin 192 of DWR as a conceptual plan to guide the formulation of projects to preserve Delta levee system integrity. Section 12226 required DWR to report to the Legislature regarding Delta levee improvements, and allowed DWR to prepare plans for Delta levee improvements and to proceed with pilot improvement studies. Section 12227 states the name of the chapter as the "Nejedly-Mobley Delta Levees Act."
1988	Delta Flood Protection Act (Senate Bill 34)	State	This Act created the Special Flood Control (California Water Code Sections project program for the eight western Delta 12310-12316; amendments to §§ 12980-12993) islands (Bethel, Bradford, Holland, Hotchkiss, Jersey, Sherman, Twitchell, and Webb) and the communities of Thornton and Walnut Grove. It amended the Delta Levee Maintenance Subvention Program established in 1973 to provide $120,000,000 in State financial assistance to local districts over a ten-year period for maintaining and improving nonproject Delta levees. Created a special account in the California Water Fund for appropriation by the Legislature to DWR for fish, wildlife, and water quality mitigation in the Delta, Suisun Marsh, and San Francisco Bay.

Table 1. Federal and State Statutes, Orders, and Regulations Affecting Flood Control (continued)

Date	Statute/Order/Regulation	Federal/State	Provisions Affecting Flood ControL
1991	Senate Bill 1065	State	Required Resources Agency to supervise (California Water Code supplementation of specified flood control and 12306,12307; amendments to levee projects, enter into a Memorandum of Bud Act of 1991) Understanding with other agencies regarding coordination and mitigation enforcement, and report annually to the legislature regarding project plans. Increased funding for the Delta Flood Protection Fund to $12,000,000 and changed related appropriations. Requires Resources Agency to annually assess whether cumulative effect of funded projects has resulted in no net long-term loss of riparian, wildlife, or fisheries habitat, and to take steps necessary to correct deficiencies causing net long-term losses.
1992	Delta Protection Act of 1992	State	Established the Delta Protection Commission, which is to develop a comprehensive, long-term resources management plan for the Delta by July 1, 1994. A basic goal of the Act is to improve flood protection by structural and nonstructural means to ensure an increased level of public health and safety.
1996	Safe, Clean, Reliable Water Supply Act	State	Provides continuous appropriation of (Cal. Water Code §§ 78540-78545; $12,500,000 for local assistance under the 78686.10-78686.12)Delta levees subvention program; and $12,500,000 for special flood control projects for eight western Delta islands and other Delta locations. Requires Department of Fish & Game review, and their approval of plans consistent with a net long-term habitat improvement plan in the Delta prior to allocating expenditures. Creates Flood Control and Prevention Account and transfers $60,000,000 to the account for pro rata allocation to various flood control projects.
1996	Water Resources Development Act	Federal	Provides emergency supplemental appropriations for recovery from natural disasters, including $4,796,000 construction funds, and $2,694,000 to repair damage caused by floods and other natural disasters. Additional $10,000,000 authorized for the cost-effective emergency acquisition of land and water rights necessitated by floods and other natural disasters.

STATE FEDERAL OPERATIONS CENTER CHART



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Source: FEAT 1997.

Figure 2

Flood Control Levees
Sacramento - San Joaquin Delta

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(CDEC) collects climatic and streamflow data from a network of Federal, State, local, and private streamflow gauges throughout California. CDEC also compiles reservoir operations information, including reservoir inflows, outflows, and storage, and provides this information to the cooperating agencies. The CDEC data is used by the NWS California-Nevada River Forecast Center and the DWR Flood Forecasting Section to produce joint river forecasts during flood season. These forecasts are available to local agencies through the CDEC computer network.

During flood operations, the USACE, the U.S. Department of Interior, Bureau of Reclamation (Reclamation), and local agencies coordinate at the Flood Operations Center. The USACE, Reclamation, DWR, and local operating agencies coordinate the management of flood control space through the Flood Operations Center to provide the maximum protection to the public. The State Office of Emergency Services (OES) coordinates the civil defense efforts of Federal, State, and local agencies during disasters or emergencies. During flood emergencies, OES maintains a liaison with the Flood Operations Center. During sufficiently large disasters and emergencies, the Federal Emergency Management Agency (FEMA) provides assistance.

Flood operations are initiated when NWS forecasts indicate that heavy rains are likely. A flood alert is called, and flood management personnel increase staffing at the Flood Operations Center. These personnel begin monitoring the forecasted storm and reservoir capacities. For all phases of a flood event, the Flood Operations Center assumes responsibility for coordinating the repair and reinforcement of existing levees, constructing emergency levees, coordinating with media and law enforcement for public notification and evacuation as necessary, and identifying flood stages and areas forecasted to be flooded. After a flood, the Flood Operations Center will help coordinate cleanup, levee repair, and reestablishment of appropriate flood pools in reservoirs.

Managing reservoir flood storage is one of the most critical activities during a flood emergency. The USACE has jurisdiction over designated flood control storage space in most of the major reservoirs. Properly managing the reservoir flood pools is necessary to prevent or reduce flooding yet maximize water storage when demand is high.

In general, reservoir water level management is governed by an approved flood control diagram. This diagram essentially defines the amount of space that should be available to store flood waters at various times of the year. Each reservoir has a unique flood control diagram that is based on the following criteria:

- the flood response characteristics of the basin,
- agreements for the level of flood protection to be provided by the reservoir,

- obligations for water conservation, and

- requirements necessary to maintain environmental conditions in the downstream water courses.

When a heavy rainfall is forecast, the Flood Operations Center, in conjunction with the USACE, will calculate the expected inflow to each reservoir. Based on the expected inflow, the release from the reservoir will be adjusted in advance of the rainfall to maintain water levels within the guidance provided by the flood control diagram. With the forecast of the end of heavy rainfall, the Flood Operations Center can reduce reservoir releases to capture the last of the flood water from an event and to maximize reservoir storage. Within the guidance of the flood control diagram and as approved by the USACE, flood management personnel exercise professional judgment on the appropriate level of flood storage to maintain at each reservoir. By managing the timing and volume of downstream water releases during floods, reservoir managers can attenuate peak flood flows and reduce risks to floodplain developments downstream.

During an actual flood emergency, flood threats are identified by on-site patrol personnel or others who may notice a potential threat. The responsible agency requests help, supplies, equipment, specialists, or flood fight crews from the Flood Operations Center. The effort is managed through the DWR Incident Command System in the field. When the incident appears to potentially exceed the resources of the responsible agency, the DWR and USACE will conduct on-site evaluations. If DWR determines the incident to be an immediate threat beyond the resources of the responsible agency and the State, and if the USACE determines that the incident meets the criteria of its legislative mandate (P.L. 84-99), the USACE assumes total management of the subsequent flood fight at that incident location.

FEMA operates in accordance with the rules and implementing regulations of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act). The Stafford Act limits FEMA to providing public assistance funds to specific eligible applicants, which include State agencies, local governments, and specific nonprofit agencies. Privately owned levees are not included (FEMA 1997).

4.4 Delta Region

The Delta lies at the confluence of the Sacramento, San Joaquin, Mokelumne, Consumnes, and Calaveras rivers. Together these rivers channel more than 47 percent of the State's total annual runoff into the Delta (DWR 1993). This runoff can become high volumes of flood waters during storms.

The following sections describe the historical perspective, current resource conditions, and levee system operations in the Delta Region.

4.4.1 Historical Perspective

The Delta was a tidally influenced marsh prior to reclamation activities in the 1850s. These activities were spurred by the need for produce to feed immigrants during the Gold Rush. Early reclamation efforts used levee systems, internal drainage, and pumps to make fertile land available for farming. Reclamation was facilitated by the Federal Swamp and Overflow Act of 1850, the State Reclamation District Act of 1861, the Federal Reclamation Act of 1902 and by the formation of the State Reclamation Board in 1911. Transformation of the Delta from marshland to farmlands separated by levees and channels was essentially complete by the 1940s.

The history of the Delta was changed by the authorization of the CVP in 1933 and the SWP in 1960. These projects consisted of a series of additions and improvements to the water storage/water transfer/flood control systems in the Delta and its tributaries. Prior to the 1940s, flooding of reclaimed Delta lands was a frequent result of levee erosion and overtopping during high flow events. Since construction of the CVP and SWP, the frequency of levee failure due to overtopping has decreased. Delta levees still fail occasionally, but the most frequent cause is either high hydrostatic pressure, resulting in piping and stability failures, or overtopping due to high tides and high winds.

4.4.2 Current Resource Conditions

The flood control facilities that protect the Delta Region include two elements:

- Levees
- Delta Cross Channel Control Gates (DCC).

An additional resource at work in the Delta Region is the system of gates that protect the Suisun Marsh from salinity intrusion during low flow periods. They also provide minimal incidental flood protection. Each of these elements are described in the following sections.

4.4.2.1 Levees

The Delta levee system initially served to control island flooding during periods of high flow. However, because of island subsidence due to peat oxidation, it is now necessary for the levee system to prevent inundation during normal runoff and tidal cycles. There are about 1,111 miles of levees in the Delta, providing flood protection to the 76 islands and tracts located there. Figure 3 shows the general locations of the Federal project levees and local nonproject levees within the Delta. Delta flooding, levee stability, levee design standards, and levee system financing are described below.

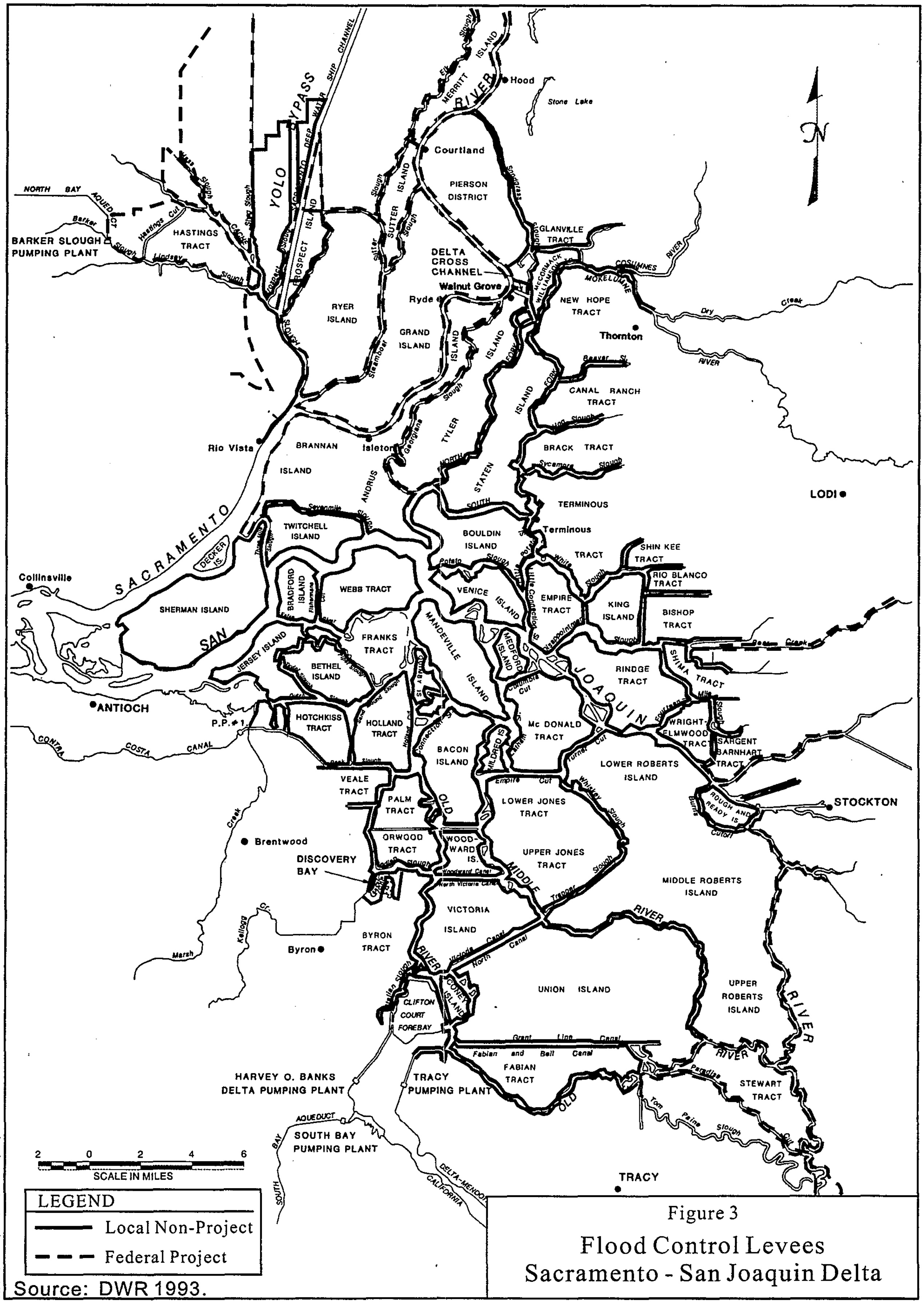

Figure 3
Flood Control Levees
Sacramento - San Joaquin Delta

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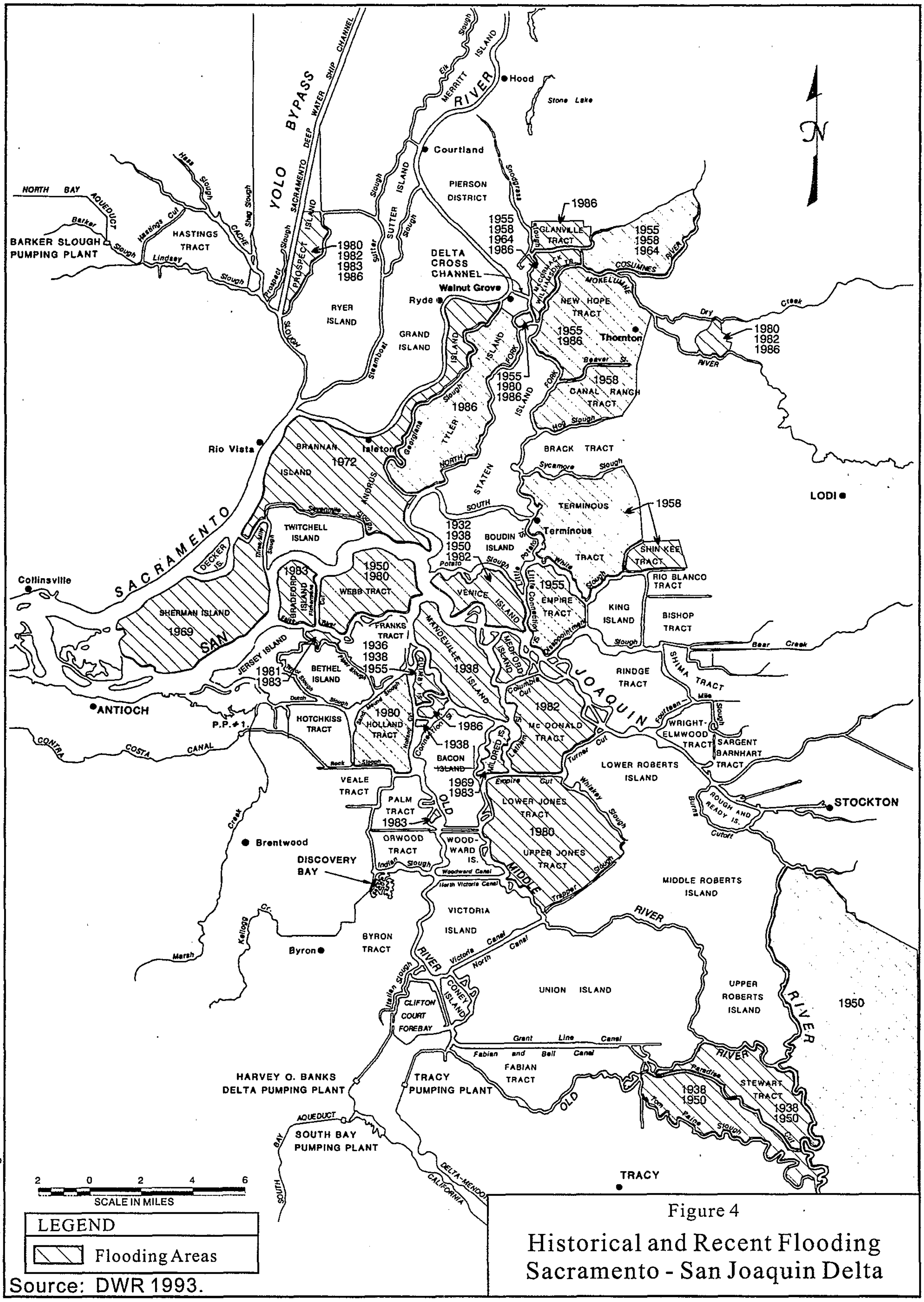
Delta Flooding

Since reclamation, each of the 70 islands or tracts has flooded at least once (DWR 1993). Prior to the Federal CVP in the 1940s, Delta flooding was characterized by the frequent inundation of vast tracts of land. About 100 failures have occurred since the early 1900s (USACE 1982). With the exception of Big Break, Little Franks, Franks, and Little Holland tracts and Little Mandeville, Lower Sherman, and Mildred islands, flooded islands have historically been restored even when the cost of repairs exceeded the appraised value of the land. In contrast, Little Mandeville Island, which was flooded in the summer of 1995, may not be restored (Figure 4).

With the advent of the large State and Federal water projects, which allow more control over flood flows, flooding generally has been restricted to inundation of individual islands or tracts resulting from levee instability or overtopping. Since 1950, the construction of upstream dams has allowed dam and reservoir managers to detain flows. This management ability and control of flood waters has further reduced the threat of overtopping. Between 1950 and 1986, 60 percent of levee failures have been due to mass instability (e.g., subsidence and hydrostatic pressure) and 40 percent has been due to overtopping (DWR 1982). Table 2 lists historic inundations of Delta islands from 1900 through 1997.

Recent flooding in the Delta occurred in 1986 on Dead Horse Island, McCormack-Williamson Tract, New Hope Tract, Prospect Island, and Tyler Island (1997 floods are not mentioned here because the study period is from 1910 to 1995). Flood flows reaching the Delta were estimated to exceed 600,000 cubic feet per second during the 1986 flood (DWR 1993). The major factors influencing Delta water stage included high flows, high tide, and wind. Historically, the highest water stages have usually occurred from December through February, when high runoff combines with high tides and wind-generated waves (BDOC 1993). Floodflow carrying capacity of rivers and channels surrounding the Delta islands is influenced by sedimentation and channel characteristics.

Figure 5 indicates Delta 100-year flood stage elevations (DWR 1993), which generally range from 6.5 to 7.5 feet above mean sea level (msl) in the western and central Delta where there is the most tidal influence. However, the 100-year flood stage ranges from 14.0 to 17.0 feet above msl in the north Delta (near New Hope Tract and Courtland, respectively) and in the south Delta (near Stewart Tract on the Old and Middle River channels) where the streamflows become dominant during large floods. These flood stage ranges (6.5 to 17.0 feet above msl) emphasize the importance of maintaining levees to varying heights and strengths throughout the Delta to protect against flooding where channel geometry and flow conditions can cause rapid stage increases during storms.



Source: DWR 1993.

Figure 4
Historical and Recent Flooding
Sacramento - San Joaquin Delta

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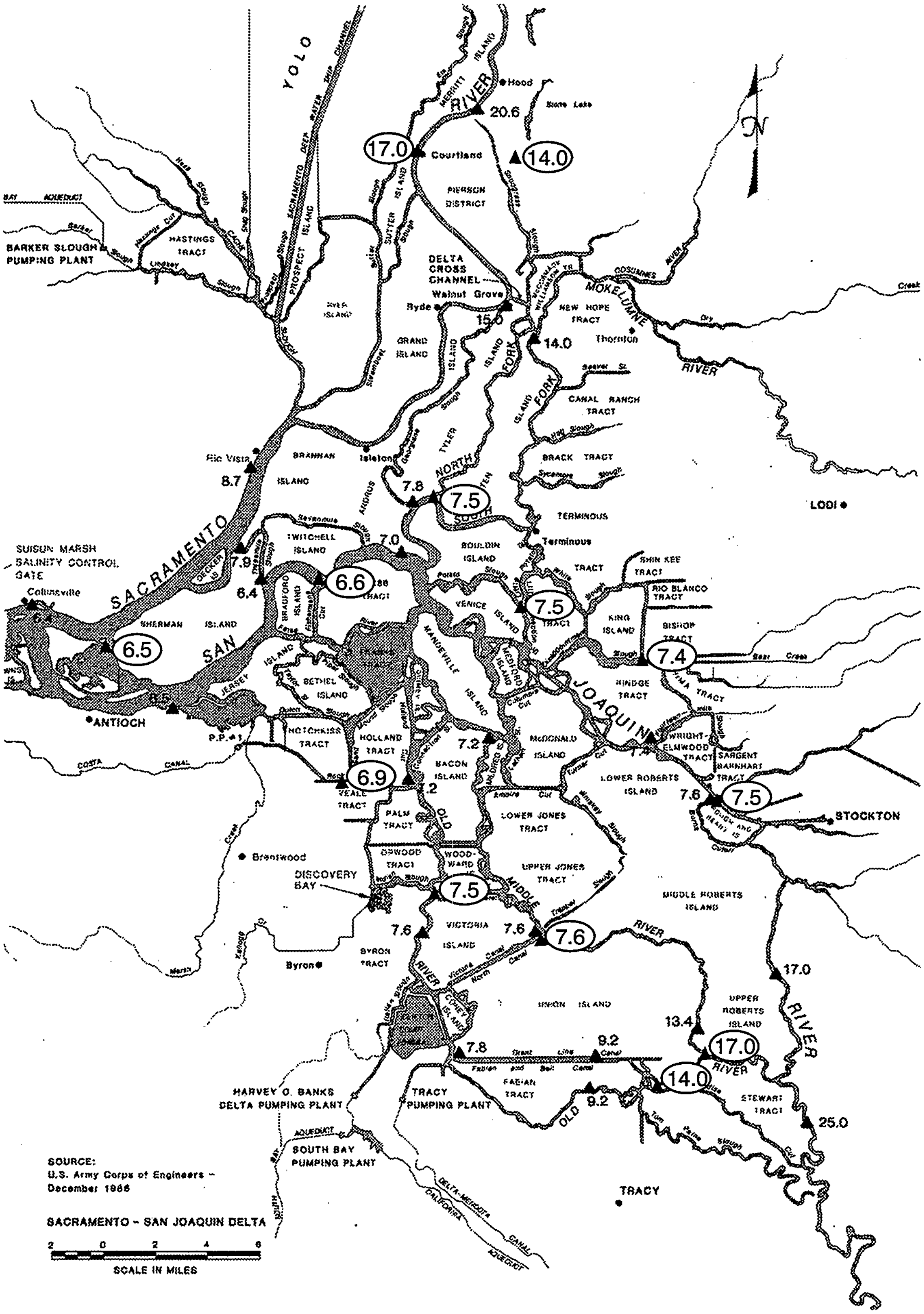

Figure 5

Flood Stage Elevations
Sacramento - San Joaquin Delta

Source: DWR 1993.

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TABLE 2 - HISTORIC INUNDATIONS OF DELTA ISLANDS

ISLANDS	ACRES FLOODED	YEAR
Andrus Island	7,200	1902, 1907, 1909, 1972
Bacon Island	5,500	1938
Bethel Island	3,400	1907, 1908, 1909, 1911, 1926
Big Break	2,200	1927, Remains Flooded
Bishop Tact	2,100	1904
Bouldin Island	5,600	1904, 1907, 1908, 1909, 1925
Brack Tract	4,800	1904, 1958
Bradford Island	2,000	1950, 1983
Brannan Island	7,500	1902, 1904, 1907, 1909, 1972
Byron Tract	6,100	1907
Canal Ranch Tract	500	1958
Clifton Court Tact	3,100	1901,1907, Remains Flooded
Coney Island	900	1907
Dead Horse Island	200	1950 1955, 1980, 1986, 1997
Decker Island	200	1986
Donlon Island	3,000	1937, Remains Flooded
Empire Tract	3,500	1955
Fabian Tract	6,200	1901, 1906
Fay Island	100	1983
Franks Tract	3,300	1907, 1936, 1938, Remains Flooded
Glanville Tract		1986
Holland Tract	4,100	1980
Jersey Island	3,400	1900, 1904, 1907, 1908, 1909
Little Franks Tract	350	1981, 1982, 1983 twice, Remains Flooded
Litttle Mandville Island	200	1980, 1982, 1986, 1994, Remains Flooded
Lower Roberts Island	10,300	1906
Lower Jones Tract	5,700	1907, 1980
Lower Sherman Island	3,200	1907, 1925, Remains Flooded
Mandeville Island	5,000	1938
McCormack-Williamson Tract	1,500	1938, 1950, 1955, 1958, 1964, 1986, 1997
McDonald Tract	5,800	1982
Medford Island	1,100	1936
Middle Roberts Island	500	1938
Mildred Island	900	1969, 1983, Remains Flooded
New Hope Tract	2,000 - 9,500	1900, 1904, 1907, 1928, 1986
Palm Tract	2,300	1907
Pescadero Tract	3,000	1938, 1950
Prospect Island	1,100	1980, 1981, 1983 Twice, 1986, 1997
Quimby Island	700	1936, 1938, 1955
R. D. 17	4,500 - 5,800	1901, 1911, 1950

TABLE 2 (continued) ISLANDS	ACRES FLOODED	YEAR
R. D. 1007	3,000	1925
Rhode Island	100	1938
Ryer Island	11,600	1904, 1907
Sargent-Barnhart Tract	1,100	1904, 1907
Sherman Island	10,000	1904, 1906, 1909, 1969
Shima Tract	2,300	1983 Twice
Shin Kee Tract	700	1938
Staten Island	8,700	1904, 1907
Stewart Tract	3,900	1938, 1950, 1997
Terminous Tract	3,000 - 10,500	1904, 1907
Twitchell Island	3,400	1906, 1907, 1909
Tyler Island	8,700	1904, 1907, 1986
Union Island	24,000	1906
Upper Jones	5,700 - 6,200	1906, 1980
Upper Roberts	500	1938
Van Sickle	2,500	1957, 1972, 1980, 1983
Venice Island	3,000	1904, 1906, 1907, 1909, 1932, 1938, 1950, 1982
Victoria Island	7,000	1901, 1907
Webb Tract	5,200	1950, 1980

Source: USACE.

Levee Stability

Levee conditions in the Delta are unique. In other regions, levees are built to protect land at elevations above normal water levels (BDOC 1993). As continuous water barriers, Delta levees need to be able to withstand flows and stages from daily runoff and tidal cycles, and high flow conditions. Delta levees also must remain fully functional during any improvements or repairs because the levees must continuously protect islands with elevations below sea level, a result of soil subsidence.

Subsidence occurs when levees protect the peat soils of the Delta from innundation. The peat soils dry up, decompose, and partly convert to a gas. This conversion results in a loss of volume in peat soils, which leads to a lowering of "interior" elevations in the Delta islands while the Delta channels maintain their elevations.

Before reclamation, the surface elevations of Delta soils were approximately at sea level. The difference between sea level and Delta land elevations represents the depth of subsidence since reclamation. The land surface of some Delta islands is subsiding at a rate of one to three inches per year (U.S. Soil Conservation Service 1989). As shown in Figure 6, some of the land in the central and western Delta is more than 15 feet below sea level. (DWR 1993). The interiors of many islands are now 10 to 15 feet below sea level.

The levees often settle under their own weight on the soft underlying foundation materials. Material has been placed on the crown of the levees

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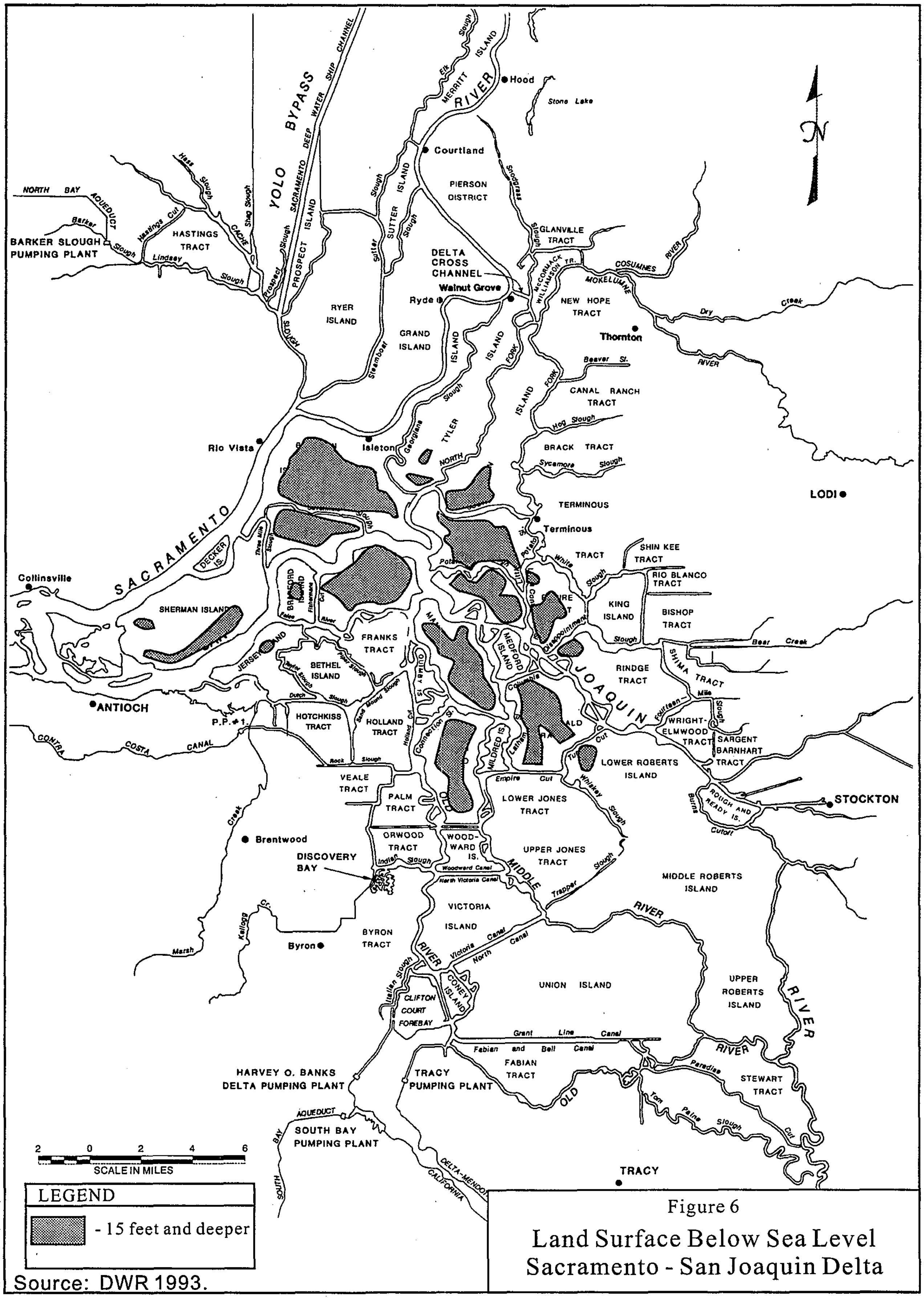

Figure 6
Land Surface Below Sea Level
Sacramento - San Joaquin Delta

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periodically to maintain height, while the interiors of the islands get lower over time. Presently, some levee crowns are 20 to 25 feet higher than the interior land surface they protect. In order to maintain stability of these high levee embankments over the relatively soft Delta soils, large berms have been added to widen the base of some levees and to act as a counterbalance to the water in the channels. The ongoing process of land subsidence therefore, has created the need for higher and wider levees and berms to protect Delta resources from floods.

Figure 7 illustrates a typical levee cross section emphasizing subsurface conditions.

Many Delta levees were constructed on heterogenous sands, silts, and clays. If used in the proper proportions and engineered correctly, sands, silts, and clays can be used to build stable levees. However, high percentages of sand or peat, within or beneath a levee, can weaken its stability.

The stability of a levee depends on the strength of its foundation and its internal strength. Specifically, factors affecting stability include levee size levee shape, composition of foundation materials, strength, overall deformability, and water pressure. While east Delta levees generally are supported by foundation materials composed of clay, silt, and sand, some central and western Delta levees are primarily resting on peat with some alluvial clay, bay mud, sand, and silt layers. While inorganic materials (sands, silts, and clays) provide adequate foundations, uncompressed peat is highly deformable and unstable (BDOC 1993).

Overall, levee system integrity is characterized as the amount of structural and foundation stability of levees. Levee vulnerability refers to a reduced level of integrity. Decreases in levee system integrity often are described as either "damage" or "failure." Levee damage refers to situations where the levee has not failed to hold back water but has suffered some decrease in structural integrity. Levee failure refers to situations where a levee has been damaged sufficiently that it either has been breached or otherwise has failed to perform its flood protection function.

There are three general mechanisms by which levees can fail, and they are often interrelated. First, a levee can be overtopped, which occurs when the stage of the flood water in the channel is greater than the height of the levee. Levee failure results from erosion on the back (land) side of the levee when water cascades over the levee crown and washes away soil until the full cross section is breached.

Levees constructed of clay soil can withstand significantly more overtopping than levees constructed of silty or sandy soil (FEAT 1997). Overtopping can occur not only as a result of flood flows, but also as a consequence of high tides and wind

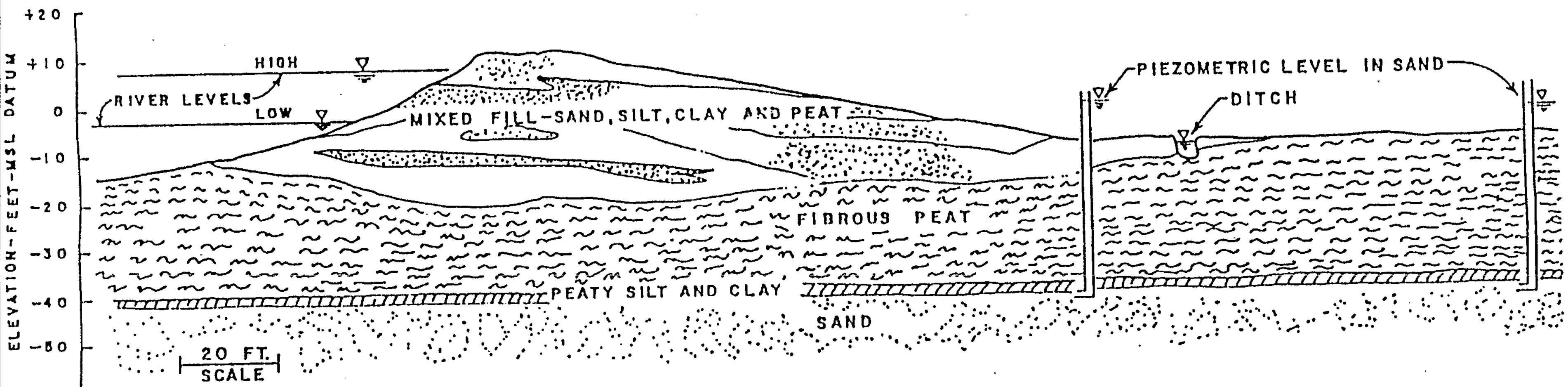

Figure 7. Typical Existing Levee Cross-Section

Source: USACE 1982.

Typical levee subsurface conditions in the Central Delta compiled from Department Of Water Resources and Corps Of Engineers Data.

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Figure8. ***Sand Boils Within Sandbag Rings Along the Levee Toe on the Right Bank of the San Joaquin River During the January 1997 Floods***
Source: FEAT 1997.

(BDOC 1993). Overtopping is of particular concern in the north Delta due to the Mokelumne and Consumnes rivers and in the west Delta due to the tidal influence and wind (BDOC 1993).

Second, levees can fail through seepage and piping. Some seepage through an earthen levee is common (FEAT 1997). However, when the seepage finds or creates a drainage path, or "pipe" through erodible material, such as sand strata, levee structural material is gradually washed out through a "boil" on the landside of the levee (Figure 8) (FEAT 1997).

If unchecked, sufficient material can exit the levee through the boil to create a large void inside the levee (FEAT 1997).

The large void weakens the internal structure of the levee and can result in a depression, or "slump," in the crown of a levee (FEAT 1997). If the crown slumps below the water surface elevation, overtopping will occur and lead to failure (FEAT 1997).

Third, a levee can fail due to instability. Levee instability can happen when high water velocity or wave action erodes material from the levee or streambank adjacent to the levee, leading to slope instability and increased seepage.

Levees can slip or slough where seepage or thorough saturation from long periods of high water weaken the levee or foundation to the point where the weight of the soil exceeds its internal strength (FEAT 1997). Levee "slippage" refers to the initial formation of a "slipface" or rotational surface within the levee that causes part of the levee side slope to rotationally slip downslope and out, leaving a large concave gouge in the levee side. Sloughing generally refers to the separation and progressive tumbling of mineral soil particles down the side of the levee when they are detached by waves or river currents.

Rotational slip is a characteristic problem for levees built of clay soil (FEAT 1997). However, this is rarely seen in the Delta, and is more frequent in regions with levees constructed of clay soils.

Sloughing can occur when seepage through the levee causes the outermost soil on the levee slope to slide down (FEAT 1997). Progressive sloughing shortens the seepage path through the levee, causing increasingly heavy seepage until the levee gives way. Sloughing is a characteristic problem of silty and sandy levees (FEAT 1997).

There are several potential factors that can damage, and eventually contribute to levee failure. These are discussed in the following paragraphs.

Seepage. Seepage from waterways or flooded adjacent islands is a major concern of Delta land users. The amount of seepage is governed by the permeability of soils, length of the seepage path, and the hydraulic head. The problem is worsened in the Delta by subsidence. Lower island interiors lead to an increase in the hydraulic head between channel/water surfaces and landside soils. Seepage can be very damaging through subsurface sand layers. Seepage has been reported to increase after flooding of an adjacent island, and to decrease after the flooded island has been drained (DWR 1982, Harding Lawson Associates 1989).

Under existing conditions, seepage can increase due to increased hydrostatic pressures from higher stages in the adjacent water channels. In addition, dredging in exterior channels can remove materials and decrease the seepage path length.

Erosion. Erosion may be caused by wind-generated waves, currents, tidal action, or boat wakes (BDOC 1993). In some reaches, bank erosion is causing retreat of expendable water-side berms, but in other areas it has proceeded into the levee. Bank retreat measurements in a narrow Delta channel subject to winter flood flows and heavy boat traffic (Georgiana Slough) revealed that over half of the observed bank retreat occurred in the nonflood season (i.e., primarily from boat wakes) (Limerinos and Smith 1975).

Erosion rates vary in the Delta. Some unprotected banks are not eroding, whereas some Sacramento River banks (within the Delta Region) are eroding at rates up to four feet per year, and some slough banks are eroding up to two to three feet per year (Water Engineering & Technology, Inc. 1991). Riprap (i.e., rock protection) typically has been used as revetment to control bank erosion (Figure 9).

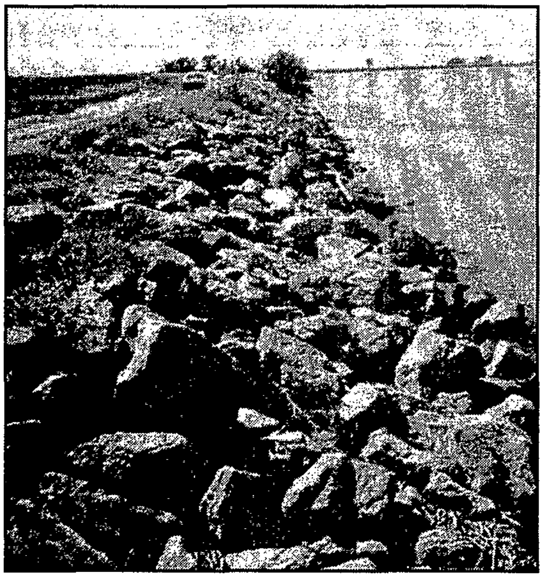

Figure 9. ***Riprap Bank Protection***
Source: DWR 1990b.

Cracks and fissures. Cracks and fissures are a stability problem and provide shorter, unobstructed pathways for piping to occur (BDOC 1993).

Deformation. Deformation may occur where levee foundations, composed of peat or other soft organic soils that have a consistency like toothpaste. If enough pressure is placed on them, the soils might squeeze out from underneath the levee, causing lateral spread (BDOC 1993).

Burrows and Roots. Rodent burrows and decaying tree root holes might increase the potential for piping to occur (BDOC 1993).

Dense vegetation. Dense vegetation on levee slopes can make it difficult and impractical (but not impossible) to detect rodent burrows and root holes (BDOC 1993). Vegetation generally controls erosion; however, continual wave action at normal water levels frequently undercuts vegetation at the waterline, and can lead to progressive caving and erosion of the levee slope (BDOC 1993).

The growth or incorporation of vegetation into riprap does not diminish and might strengthen the revetment, as was observed at sites upstream of the Delta along the Sacramento River (Water Engineering & Technology 1991; Shields 1991).

Encroachment of Structures. Encroachment of structures on levee slopes might reduce the protection provided by the levee system and make levee inspection, maintenance, and improvements more difficult (BDOC 1993).

Subsidence. Subsidence is a major concern in the Delta because it increases the water pressure on levees and, therefore, the probability of levee failure and flooding. The U.S. Geological Survey, in cooperation with DWR, evaluated causes of subsidence in the Delta and concluded that reclamation and agricultural activities have caused land subsidence ranging from one to three inches per year in the Delta (Rojstaczer et al. 1991).

Settlement. Settlement occurs when the construction of Delta levees over soft soils has caused consolidation of their foundations and settlement into the land surface. This settlement occurs at different rates, depending on the variable level of consolidation of the underlying soils at any location along a levee. Levee segments can settle at different

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rates. This process is generally referred to as differential settlement. Long reaches of Delta levees are therefore subject to differing levels of cracking, seepage, and instability because of differential settlement between adjacent segments of the same continuous levee. To compensate for settlement, material is periodically added to levees to increase their height. The effect of adding materials to levees continues to increase the load on the underlying materials, causing more settlement, and the cycle repeats itself. Levees settle at various rates, depending on the nature of underlying material and the length of time since the levee crown was last raised with additional fill (Harding Lawson Associates 1989).

Delta levee stability also is affected by seismic hazards. Faults are considered active if they have moved at least once during the last 11,000 years. Active faults that can produce significant (i.e., potentially damaging) accelerations in the Delta Region are present (DWR 1982). The more prominent faults include the Antioch, Calaveras, Green Valley or Concord, Greenville, Hayward, Rodgers Creek, Sierran Block Boundary Zone (or Winters-Vacaville), and San Andreas (Finch 1992).

An earthquake could cause levee failure through lateral deformation, settlement, or liquefaction. Delta levees are constructed of, and are on top of, sand and silt. These materials, when saturated, are known to lose cohesive strength when subjected to the seismic acceleration of an earthquake. This effect is commonly referred to as liquefaction. A recent geotechnical study to assess the potential for liquefaction along the Delta levee system found liquefiable sand to be widespread beneath the levee systems on most of the Delta islands and concluded that the susceptibility of the Delta levees to earthquake-induced liquefaction is high (Finch 1992). Even though liquefiable soils are present, if they are at depth or confined beneath the levee, liquefaction might not cause any damage to the levee.

A review of available information indicates that, between 1808 and 1996, approximately forty-one earthquakes with magnitudes of 4.5 and above on the Richter Scale occurred in the region within or immediately surrounding the Delta (Figure 10). Five of these historical events had recorded intensities of Modified Mercali Intensity (MMI) VI or greater. However, none are believed to have induced even moderate levels of shaking in the Delta Region. The bedrock and stiff soil sites at the periphery of the Delta have experienced peak accelerations no higher than about 0.lg to 0.15g (g = acceleration due to gravity) (Working Group 1996). Within the central portions of the Delta, base motions would be expected to have been less than 0.2g. Even the 1906 San Francisco Earthquake is estimated to have generated peak ground accelerations of 0.08g or less within most of the Delta Region.

In an effort to estimate probable bedrock motions beneath the Delta

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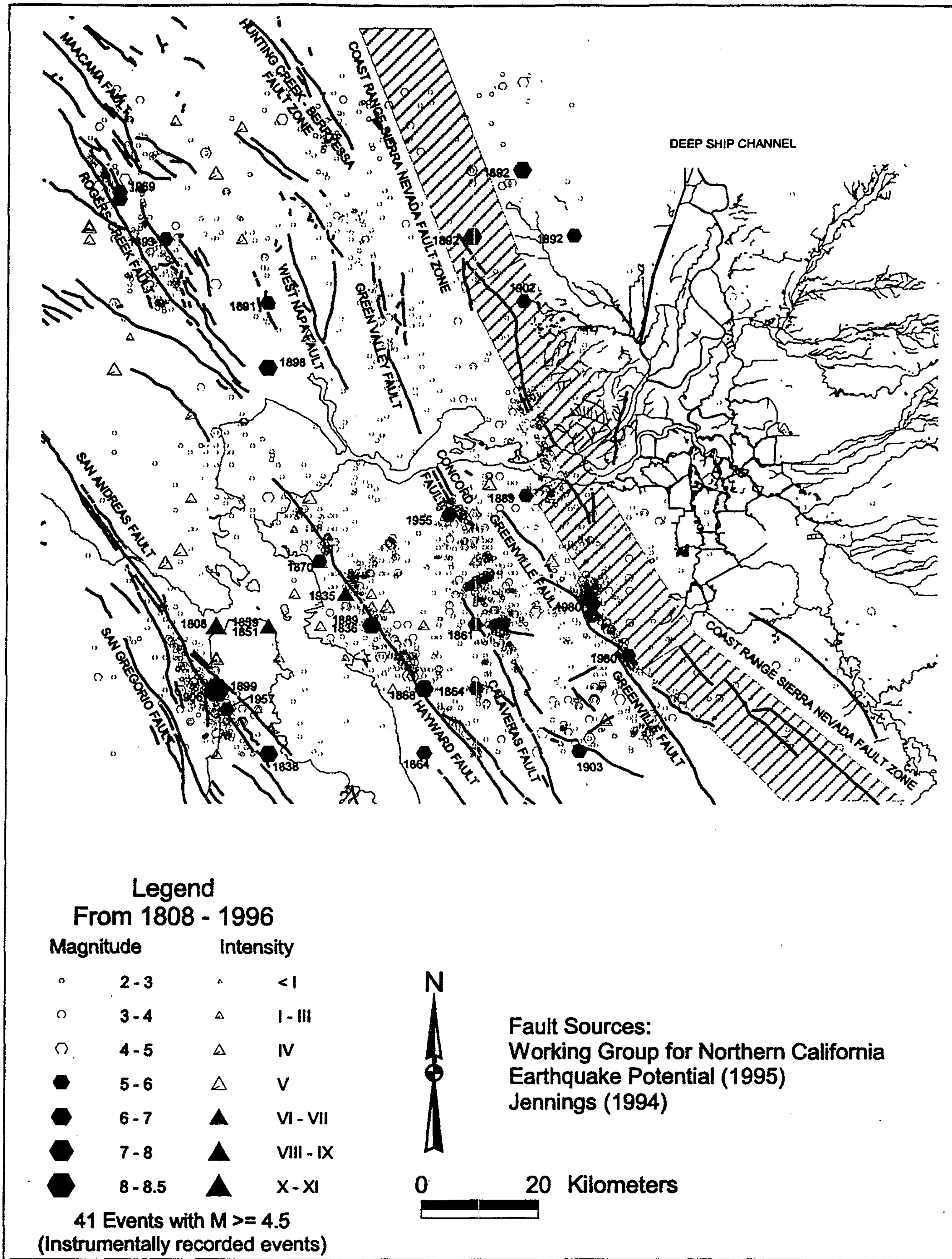

BAY DELTA FLOOD CONTROL ANALYSIS

SOURCE: Working Group 1995.

Seismicity and Faults in the Bay Delta Region

Figure 10

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within the next 30 years, the DWR performed a probabilistic seismic hazard analysis (DWR 1992). The analysis indicated that for a 90 percent probability on nonexceedance in a 30 year period, peak bedrock accelerations of 0.35g and 0.15g were estimated for the western and eastern margins, of the Delta respectively (DWR 1992)

There is no evidence that a levee in the Sacramento-San Joaquin Delta has ever failed as a result of earthquake shaking. Moreover, there is no evidence of any Delta levee having experienced significant damage as a result of earthquake shaking. The most serious damage in the Delta attributed to an earthquake appears to have been the approximately three feet of settlement reported for a Santa Fe Railroad bridge at the Middle River crossing during the 1906 San Francisco Earthquake.

This lack of reported damage, however, does not indicate a seismically strong levee system. The Delta levee system has been in place only a short time relative to the long period typical of large earthquakes. The strongest earthquake loadings probably occurred during the 1868 Hayward and 1906 San .Francisco earthquakes of magnitude 6.8 and 8 on the Richter Scale. During these events, the levee system was not fully developed (the levees were generally less than half their current height), and the ground accelerations were dampened by the distance to the quake epicenters .

Levee Design Standards

The condition of the Delta levees is typically described as meeting one of the following five general standards which are compared in figures 11 through 15.

None: little or no freeboard above the 100-year stage.;

HMP: provides 100-year protection with at least one foot of freeboard above the 100-year-flood elevation, a minimum crown width of 16 feet, waterside slopes of 1.5 horizontal to 1 vertical, and landside slopes of 2 horizontal to 1 vertical. Reclamation districts must have met this standard by 1991 to receive future Federal disaster relief (Figure 11)

Federal Emergency Management Agency (FEMA) 100-year: provides 100-year protection with at least three feet of freeboard above the 100-year flood elevation for urban areas. Minimum crown width is 16 feet. Waterside slopes are two horizontal to one vertical. FEMA allows variable landside slopes, but requires proof of structural stability. Levees that meet these standards qualify landowners for generally lower flood insurance rates and fewer floodplain management restrictions under the National Flood Insurance Program (Figure 12).

Public Law 84-99: provides 100-year protection with at least 1.5 feet of freeboard above the 100-year-flood elevation and a minimum crown width of 16 feet. Landside slopes vary from three horizontal to one vertical; tofive horizontal to one vertical, depending on the height of the levee and the depth of peat. Waterside slopes are two horizontal to one vertical. Levees that meet or exceed Public Law 84-99 design standards qualify for Federal post-disaster rehabilitation assistance (Figure 13).

Bulletin 192-82: provides 300-year flood protection with at least 1.5 feet (agricultural uses) and three feet (urban uses) of freeboard above the 300-year-flood elevation. Landside slopes vary from three horizontal to one vertical to seven horizontal to one vertical, depending on the height of the levee and the depth of peat. Waterside slopes are two horizontal to one vertical. Levees that meet or exceed Bulletin 192-82 design standards qualify land owners or reclamation districts to receive Delta Levee Subventions Program funds and would allow them to receive USACE certification for Public Law 84-99 funds (Figures 14 and 15).

Levee Maintenance

In 1995, DWR inspected and reported on the status of maintenance of flood control levees, channels, and other works operated under cooperative arrangements among Federal, State, and local public entities (DWR 1996b). This was done under the authority of California Water Code sections 8360, 8370, and 8371, consistent with 33 C.F.R. § 208.10.

Levees were inspected once in the spring and once in the fall. The inspections verify, for both the Sacramento and San Joaquin river systems, that local agencies are performing their legal and statutory responsibilities, pursuant to Water Code Sections 12642 and 12657, and are meeting their legal obligations, under assurance agreements with the State, to operate and maintain their flood control projects "on any stream flowing into, or in, the Sacramento Valley or the San Joaquin Valley"(DWR 1996b).

Levee Financing

Costs of maintaining and repairing the levee system in the Delta are substantial (DWR 1982, 1993). State and local governments have invested millions of dollars in the past 10 years to maintain and repair eroded levees. In some instances, the expenditures exceeded the appraised value of the island or tract being protected. The average annual cost of levee maintenance on nonproject levees in the Delta ranged from $3,000 to $165,000 per levee mile, averaging $11,800 per levee mile between 1981 and 1991. From 1981 to 1991, $63 million was spent to repair levees, $26 million of which was contributed by the State's levee maintenance subventions program. (DWR 1993).

Beginning in 1988, State cost-sharing authorization was increased to 75 percent of costs exceeding $1,000 per mile under the Delta Flood Protection Act of 1988 (Act). Under the 75 percent cost-share proportion established by the act, the State cost could increase to approximately $170,000 per year, or

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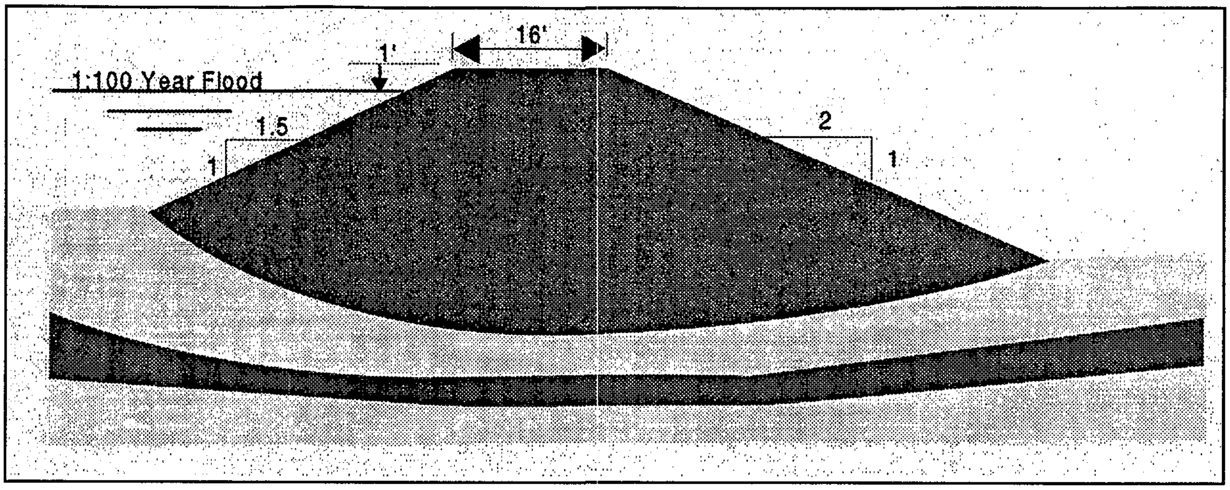

Figure 11. Hazard Mitigation Plan (HMP) (Agriculture)
Source: BDOC 1993.

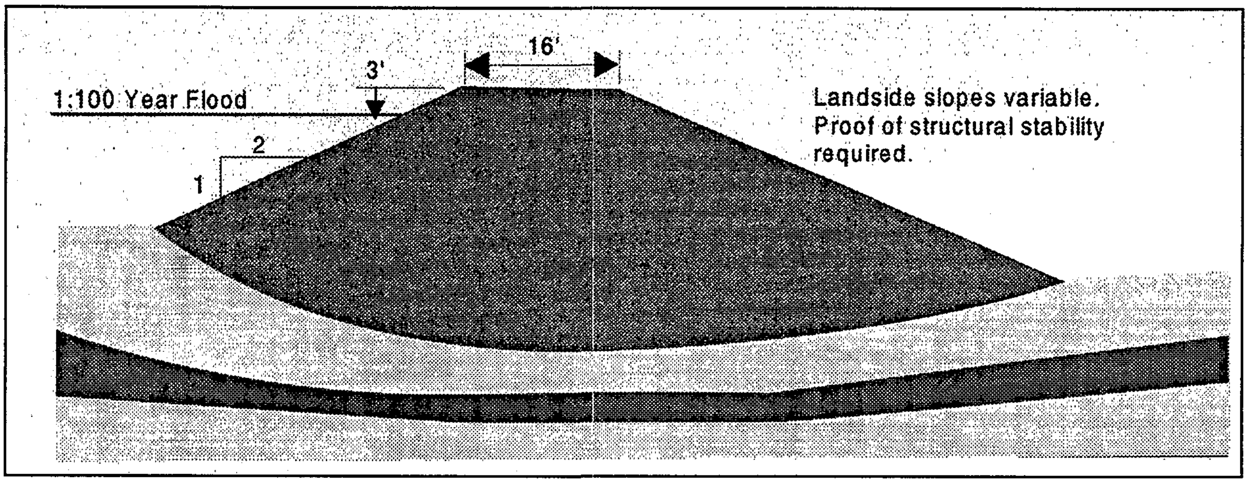

Figure 12. FEMA (Urban)
Source: BDOC 1993.

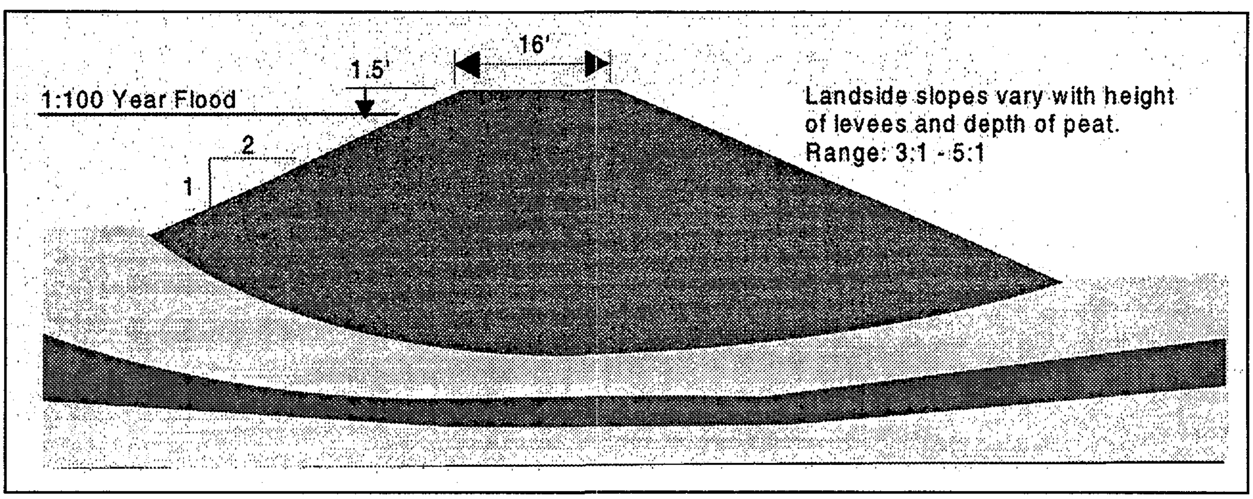

Figure 13. PL 84-99 Standards (Agriculture)
Source: BDOC 1993.

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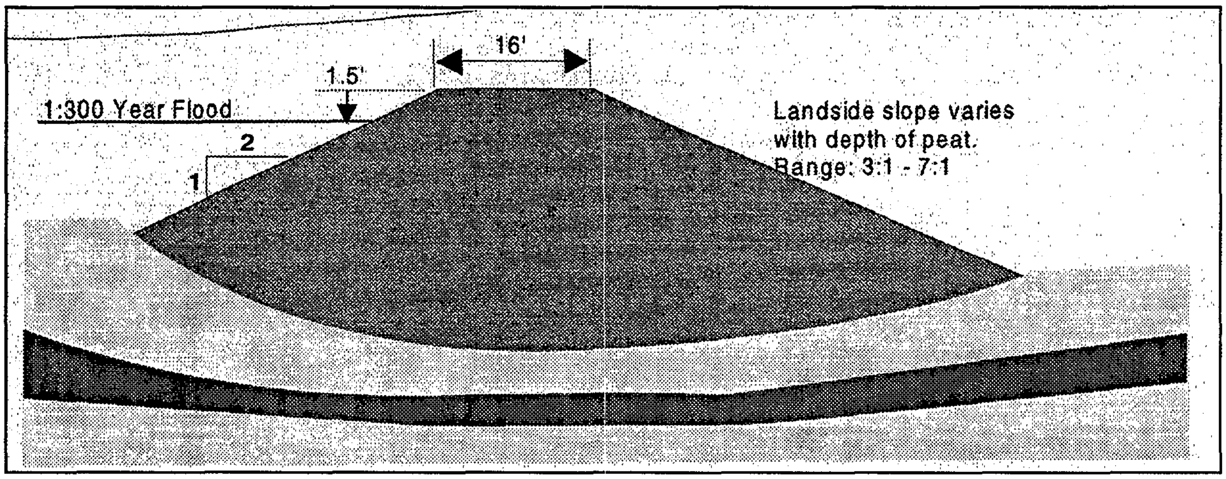

Figure 14. DWR Bulletin 192-82 (Agriculture)
Source: BDOC 1993.

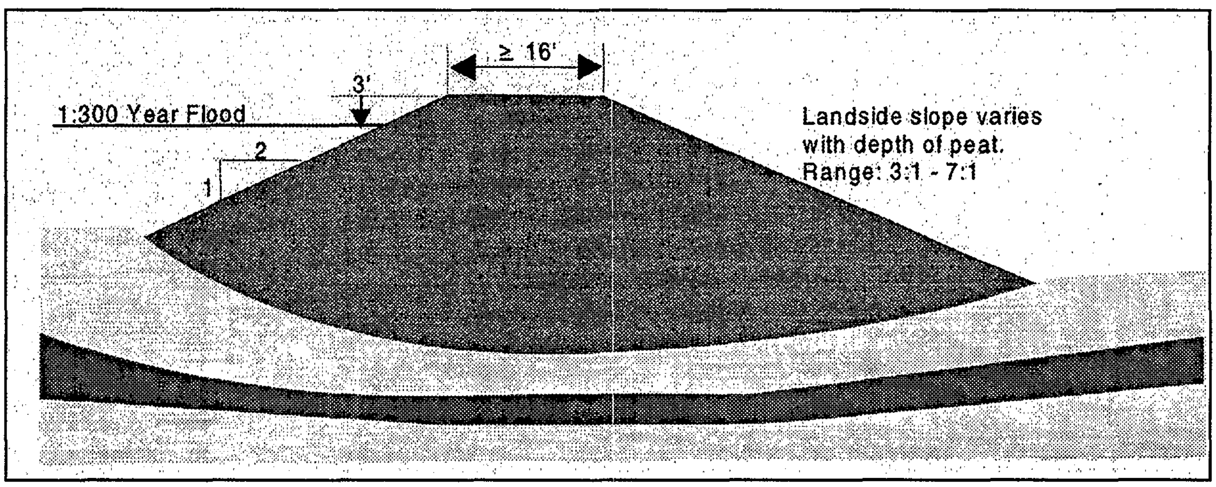

Figure 15. DWR Bulletin 192-82 (Urban)
Source: BDOC 1993.

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$8.5 million over 50 years, if projections are based on experience from 1981 to 1991. This cost to the State is approximately twice current costs.

The Delta Flood Protection Act provided $60 million over 10-years to control subsidence and rehabilitate levees on eight western Delta islands and an additional $60 million for Delta-wide levee maintenance and upgrades (DWR 1988).

Emergency expenditures by the Federal and State governments under FEMA and the Natural Disaster Assistance Act, respectively, from 1980 to 1986 was $97.3 million ($65 million FEMA, $26.5 million Natural Disaster Assistance Act, and $5.8 million by local sponsors). The cost per acre of island of these repairs ranged from less than $10 to $4,000 (DWR 1988).

4.4.2.2 Delta Cross Channel Control Gates

DCC Gates are closed during high flows and floods on the Sacramento River. During floods, when stages on the Sacramento River exceed those on Mokelumne River channels, the gates prevent water from spilling out of the Sacramento River into the Mokelumne River and flooding leveed and unleveed lands. If storms hit central California while the river stages are lower on the Sacramento River, the DCC gates can be opened to spill high flows out of the Mokelumne System and to reduce stages on the north and south forks of the Mokelumne. This transfers flood water from the nonproject levees of the Mokelumne River to the Sacramento River, which is protected with project levees.

4.4.2.3 Suisun Marsh Salinity Control Gates

The Suisun Marsh Salinity Control Gates project was implemented in 1989. The gate system works primarily to protect the marsh from the saline waters of the bay during periods of low Delta outflows. The Suisun Marsh Salinity Control Gates do not play a specific role in flood control but are part of the affected environment which should be considered during CALFED solution evaluation.

4.4.2.4 Flood Control System Operation

Unlike the system of reservoirs and weirs that control the magnitude of flooding on the rivers upstream of the Delta, the flood control system in the Delta (aside from the Delta Cross Channel Control Gates) operates passively. However, the levee system does require maintenance, monitoring, and improvement, particularly during floods, to maximize the level of protection provided by the levee system.

4.5 Bay Region

The Bay Region includes all portions of the Sacramento-San Joaquin System drainage downstream from the east end of Carquinez Strait (west end of Suisun Bay) to the Pacific Ocean at the Golden Gate. The following sections describe the historical perspective and current resource conditions of the Bay Region.

4.5.1 Historical Perspective

The land in the Bay Region historically has suffered little from Sacramento-San Joaquin River system flooding. Extensive flooding has occurred in the Bay Area due to local runoff during intense rainstorms. The broad, deep channels and large bays downstream from the Suisun Marsh have not demonstrated significant variability in water level beyond that which occurs as a result of natural tidal fluctuations and sea level rise. Historical records indicate that sea level has been rising (DWR 1992). If the trend continues, rising sea level has the long- term potential to intensify flooding, worsen water quality, and complicate water management in the Delta.

Bay water is usually saline to brackish, making reclamation of the surrounding marsh lands unattractive for agricultural purposes. Improvements to control flooding therefore have been minimal and now are directed mainly toward ecological habitat creation and preservation.

4.5.2 Current Resource Conditions

No significant flood control resources are at work in the Bay Region to control floods emanating from the Delta.

4.6 Sacramento River Region

The Sacramento River Region is bounded by the Sierra Nevada Mountains on the east, the Coast Ranges on the west, the Cascade Range and Trinity Mountains on the north, and the Delta Region on the south. The Sacramento River is the principal river in the basin. Its major tributaries are the Pit and McCloud rivers, which join the Sacramento River from the north, and the Feather and American rivers, which join it from the east. Numerous minor tributary creeks flow from the east and west. The average runoff from the basin is second only to the North Coastal Basins and is estimated at 21,300,000 acre-feet per year (USACE-SPD 1979). The melting snowpack in the Sierra Nevada generally maintains streamflows up to midsummer. Although spring snowmelt can cause flooding on the Sacramento River, extreme flood events are almost always triggered by intense rainfall.

The following sections describe the historical perspective and current resource conditions of the Sacramento River Region.

4.6.1 Historical Perspective

The bottomlands of the Sacramento River Region consisted of tule marshlands prior to the Gold Rush of the mid-19th century. Before the beginning of agricultural development in the Sacramento Valley, large portions of the valley were subject to periodic inundation by flood flows from the Sacramento River and its tributaries.

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The floodplains varied in width from two to 30 miles (Jones & Stokes 1987).

Individual landowners began flood control system development in the mid 1800s when the Gold Rush increased demands for food. By 1894, many miles of levees had been completed, and some areas had formed flood protection districts. These first levees were constructed by hand and were demonstratively inadequate, based on the damage that occurred during high flow periods (WET 1991).

This damage was accentuated by hydraulic mining in the mountains. The mining activities resulted in large volumes of silt, sand, and gravel being deposited into the rivers in the Sacramento Basin. These sediments were deposited in the channels and increased the flood stages associated with high flow events by reducing channel capacity. Hydraulic mining activities essentially stopped in 1893.

Federal flood control activities were initiated in 1917 when Congress authorized the Sacramento River Flood Control Project. This project consisted of a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, overbank floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River. The effectiveness of the Sacramento River Flood Control Project was increased by the completion of multipurpose reservoirs that provide flood control storage. The reduction of the flood hazard has encouraged extensive development in the protected areas and has prevented billions of dollars in flood damage since project completion (USACE-SPD 1979).

Multipurpose reservoirs and a system of weirs and bypasses contribute to the flood control system in the Sacramento Basin by storing or diverting water during periods of high runoff, thereby reducing the load placed on the levee system during floods. These elements have been established by a variety of State and Federal funded projects.

4.6.2 Current Resource Conditions

The flood control resources at work in the Sacramento River Region include levees, reservoirs, weirs and bypasses.

Each of these elements and a brief discussion of how they work together to provide flood control are described below.

4.6.2.1 Levees

Stability issues affecting the project levees in the Sacramento River Region include settlement, erosion, and seepage. These issues are discussed in the section on Delta Levees (Section 4.4.2.1) although soil conditions are different.

The project levees in the Sacramento River Region are illustrated on Figure 16. Nonproject levees are present in the Sacramento River Region, but these levees are not significant to the

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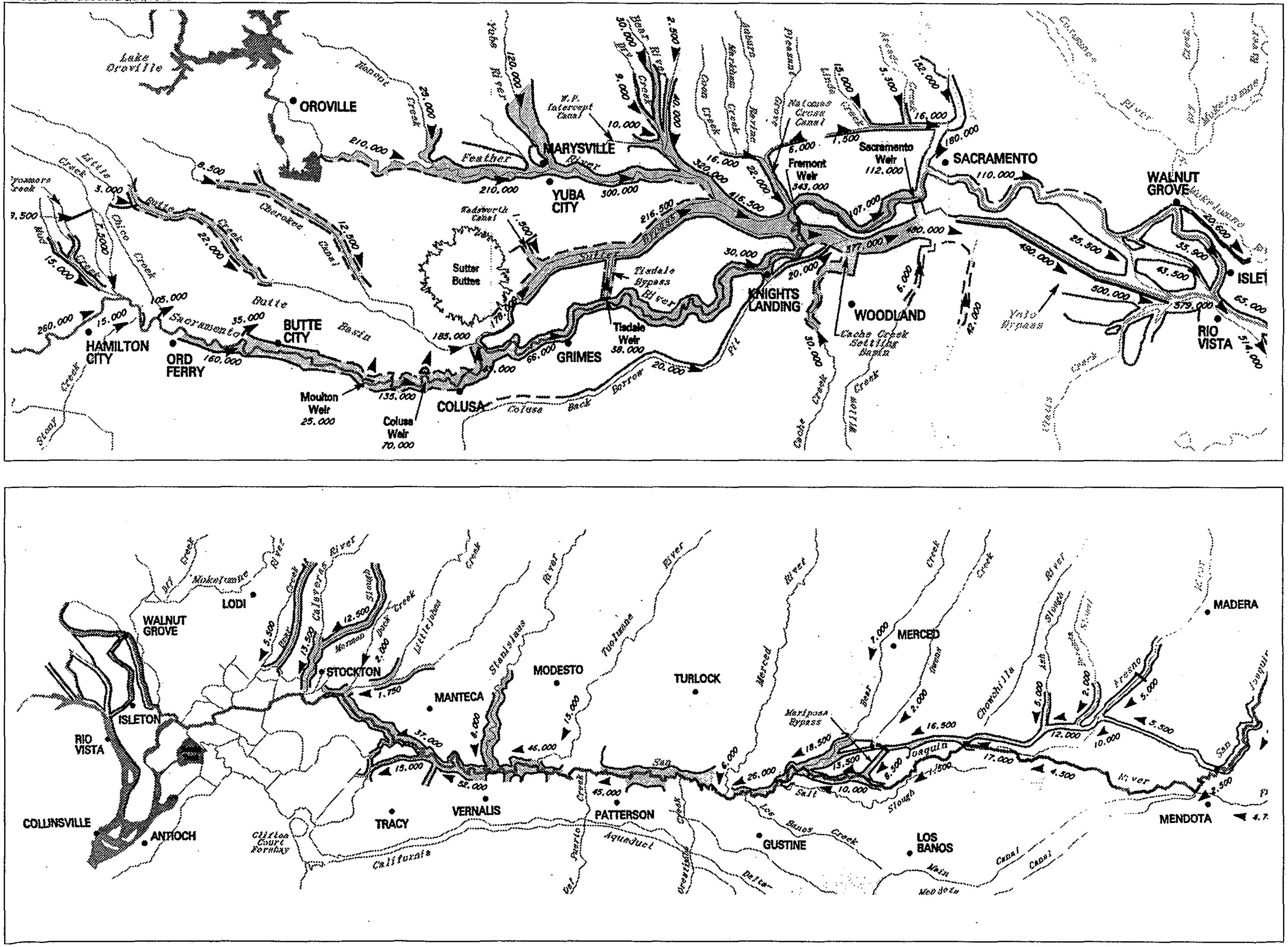

Figure 16. Sacramento River (top) and Delta-San Joaquin River (bottom) Flood Control Systems

Source: FEAT 1997.

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overall level of flood control protection at work in the basin.

Sacramento River Flood Control Project levees are characterized by wide variations in levee embankment and foundation soil conditions that frequently can occur over short vertical and lateral distances (USACE 1995). Results from geotechnical studies conducted by USACE in 1992 indicated that the primary concern along the Sacramento River related to levee embankment integrity in the Upper Sacramento River area is the susceptibility of levee embankment and foundation soils to seepage and piping (USACE 1995). For example, along the Colusa Basin Drain and Knights Landing Ridge Cut, levee stability is related to the type of material in the levee (such as fat clays, lean clays, and organic layers, etc.) and cross-section geometry (USACE 1995). Historically, levee cracking due to wet-dry cycles followed by a flood have resulted in numerous slope failures, both on the landside and waterside (USACE 1995). These slope failures generally are shallow—four feet or less (USACE 1995). Vegetation along the waterside bank of the Colusa Basin Drain is noted as having a stabilizing effect (USACE 1995).

4.6.2.2 Reservoirs

Major reservoirs that provide flood protection to the Sacramento River Region include the following:

- Black Butte Reservoir,
- Camp Far West Reservoir,
- Clair Engle Lake,
- Clear Lake,
- East Park Reservoir,
- Englebright Reservoir,
- Folsom Lake,
- Lake Almanor,
- Lake Oroville,
- New Bullards Bar Reservoir,
- Rollins Reservoir,
- Shasta Lake,
- Stony Gorge Reservoir, and
- Whiskeytown Reservoir.

These reservoirs were constructed and are maintained by a variety of State, Federal, and cooperative projects.

4.6.2.3 Weirs and Bypasses

A system of weirs and bypasses was constructed by USACE on the Sacramento River. The system includes three bypasses, the Butte Basin, Sutter Bypass, and Yolo Bypass. The bypasses are fed by the Moulton and Colusa weirs which feed into the Butte Basin Bypass, the Tisdale Weir which feeds into the Sutter Bypass and the Fremont Weir, which feeds into the Yolo Bypass.

When flooding occurs, the weir and bypass system diverts water to protect the levee system and frees flood storage capacity in the reservoirs. The weir system works by diverting flood waters in the leveed rivers into the bypasses. The bypasses are large tracts of undeveloped or minimally developed land. Development within the bypasses typically is limited to agricultural activities that require minimal infrastructure. Water released to the Butte/Sutter/Yolo bypass system flows south, towards the Delta, in effect creating a short-term storage system for the floodwaters. Additionally, a significant volume of the water released to the bypass system infiltrates into the ground, recharging groundwater supplies–although this volume is small compared to the total volume of a flood.

4.6.2.4 Flood Control System Operations

The flood control system goes into action days before a flood. Based on weather forecasts of heavy rains or weather conditions that could produce heavy runoff from the Sierra snow pack, reservoirs can begin releasing higher than usual flows to the river system. The higher than usual flows will create additional capacity in the reservoirs without overstressing the levees or unprotected banks downstream. If and when the flood occurs the reservoirs can retain the high volume flows and store the water for later release during the days and weeks after the flood event. The system allows flood waters to be transported downstream in a controlled manner starting days before and continuing until weeks after a flood.

By varying the amount of water kept in reservoirs during different times of the year, the system can be modified to maximize flood control capabilities during the early part of the flood season and to maximize water storage later as the flood risk abates. The water stored in the reservoirs generates power to maintain fisheries flows during dry periods, and supplies municipalities and industries.

When flooding occurs, the weir and bypass system is used to divert water to protect the levee system and to free up flood storage capacity in the reservoirs. The weir system works by diverting flood waters from the leveed rivers into the bypasses. The bypasses are large tracts of undeveloped or minimally developed land. Development within the bypasses is typically limited to agricultural activities which require minimal infrastructure. Water released to the Butte/Sutter/Yolo bypass systems flows south, towards the Delta, creating, in effect, a short term storage system for the floodwaters. Additionally, a significant volume of the water released to the bypass system infiltrates into the ground, recharging groundwater supplies-although this volume is small compared to the total volume of a flood event.

By storing water in reservoirs and bypasses, the flood control system can minimize the peak flows that the river and levee system are required to handle. The levee system increases the magnitude of floods that the river system can handle without occupying the entire floodplain.

The Sacramento River Region levee system, along with the reservoirs, weirs, and bypasses, which initially served to protect farmlands, are now necessary to protect those same farmlands, along with some urban areas.

4.7 San Joaquin River Region

The San Joaquin River Region extends generally from Stockton on the north to near Fresno on the south, and from the Coast Range on the west to the Sierra Nevada on the east (Figure 1). The major river system in the region is the San Joaquin River, and its major tributaries are the Stanislaus, Tuolumne, Kings, and Merced rivers. Despite extensive diversions, snowmelt from the Sierra Nevada and agricultural drain waters generally maintain some level of flow in the San Joaquin River and major tributaries throughout the summer –except near Gravelly Ford, where the river infiltrates the porous river bed. The Chowchilla and Fresno rivers are the largest of its minor tributaries, most of which are dry during the summer. Average annual runoff from the San Joaquin River and its major tributaries is estimated at about 6,000,000 acre-feet (USACE-SPD 1979). The Consumnes River, Mokelumne River, Calaveras River, and Dry Creek are also part of the San Joaquin River Region. These rivers do not become tributary to the San Joaquin River until they are within the Delta Region. In years of exceptionally heavy snowmelt, spill from the Tulare Lake Basin to the south flows northward into the San Joaquin River system.

The following sections describe the historical perspective and current resource conditions of the San Joaquin River Region.

4.7.1 Historical Perspective

Work on flood control projects in the San Joaquin River Region was begun early in the 20th century. Improvements have included the construction of levees, bypasses, maintenance or improvement of stream channels, and the completion of a system of reservoirs. These projects have been completed primarily to provide flood control and to augment agricultural opportunities.

4.7.2 Current Resource Conditions

The flood control resources currently employed in the San Joaquin River Region include levees, reservoirs, weirs, and bypasses.

Each of these elements and a brief discussion of how they work together to provide flood management are described below.

4.7.2.1 Levees

Stability issues affecting the project levees in the San Joaquin Basin include settlement, erosion, and seepage. These issues are discussed in the Section on Delta Levees (Section 4.4.2.1).

The project levees in the San Joaquin River Region are illustrated in Figure 16. Nonproject levees are present in the San Joaquin River Region, but they are not significant to the overall level of flood control at work in the basin.

Reconnaissance studies done by USACE on levees on both banks of the San Joaquin River, from Friant Dam downstream to Old River, Mariposa Bypass, Eastside Bypass, and Chowchilla Bypass, indicated that materials used to construct levees on the San Joaquin River mainstem generally range from clay to silty sand (USACE 1993b). Evaluations of levee reaches ranged from "fair" to "acceptable and well-maintained" to "good" (USACE 1993b). Overall, the flood control project features were summarized as "adequate" (USACE 1993b). The primary problem is a lack of maintenance. Local bank protection is needed. Set back levees in some reaches may be needed in the future (USACE 1993a). Since the levees were inspected during relatively low summer water levels, seepage conditions could not be fully evaluated (USACE 1993b). To evaluate the potential for seepage problems, the levees should be inspected during flood conditions. In addition, explorations would be required where seepage or stability problems are reported (USACE 1993b).

4.7.2.2 Reservoirs

Major reservoirs that flood protect for the San Joaquin Basin from floods include the following:

- Hensley Lake,
- H.V. Eastman Lake,
- Millerton Lake,
- New Exchequer Reservoir,
- New Melones Lake,
- Pine Flat Lake, and
- Tuolumne River Reservoirs (Cherry Valley and New Don Pedro Lakes).

These reservoirs were constructed and are maintained by a variety of State, Federal, and cooperative projects.

4.7.2.3 Weirs and Bypasses

A system of weirs and bypasses has been established on the San Joaquin River system. The system includes three bypasses (the Mariposa, Eastside, and Chowchilla bypasses) fed by weirs.

4.7.2.4 Flood Control System Operation

The levee and reservoir system in the San Joaquin Basin is operated to control floods using the same methods as described in Section 4.6 (Sacramento River Region). Although the San Joaquin Valley typically does not experience the same intensity of rainfall-induced floods as other watershed basins in northern California, it must contend with snowmelt floods.

4.8 SWP and CVP Service Areas Outside of the Central Valley

The SWP and the CVP are two projects that store and release water upstream of the Delta and export water from the Delta to areas generally south and west of the Delta. Water project facilities are illustrated in Figure 17. The following sections describe the historical perspective and current resource conditions associated with the SWP and CVP.

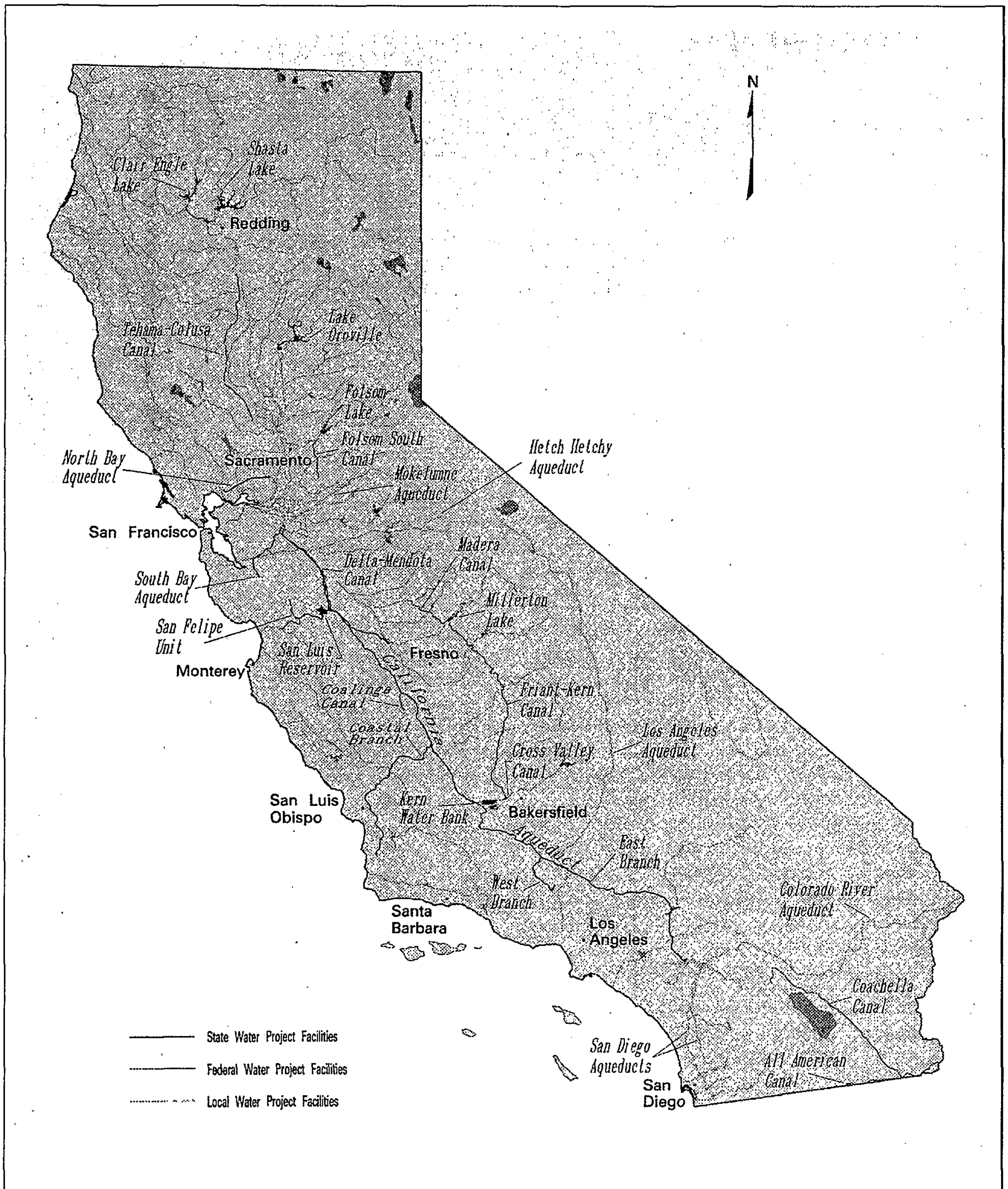

Figure 17

Water Project Facilities in California

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4.8.1 Historical Perspective

The CVP was authorized by Congress is 1933. The SWP was authorized by voters in 1960 (Table 1). These projects were initiated primarily in response to the increased demand for water by agricultural, industrial, and urban users in the arid southern portion of the State.

4.8.2 Current Resource Conditions

Flood control resources provided by the SWP and CVP are limited to the on-stream reservoirs in the Sacramento and San Joaquin basins. These resources are described in Sections 4.4, 4.6, and 4.7.

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6.0 GLOSSARY

Crown - Top of a levee.

Erosion - The wearing away of the land surface by various processes, the most important being river currents and waves.

Freeboard - The vertical distance between normal maximum water level; an allowance in protection above the design water surface level. The distance between the elevation of the water surface and the elevation at which overtopping of a levee or spillway will occur.

Hundred-year flood - The probability in any given year that there is a one in one-hundred flood event.

Hydraulic head - The pressure exerted by water on a unit area because of the height at which the water surface stands above the point where the pressure is determined.

Hydrostatic pressure - The pressure of water at a given depth resulting from the weight of the water above it.

Levee - An embankment, generally constructed close to the banks of a stream, lake, or other body of water, intended to protect the landside from inundation or to confine the streamflow to its regular channel.

Liquefaction - The process in which saturated sandy soil loses cohesion when subject to ground shaking during an earthquake.

Oxidation - The conversion of organic soil, such as peat, to carbon dioxide.

Piping - The process of seepage carrying away levee material resulting in larger seepage paths within the levee.

Revetment - A facing of stone, concrete, sandbags, or other materials used to protect a bank of earth from erosion; such as riprap.

Seepage - A slow movement of water through permeable soils caused by hydraulic head.

Seismicity - The frequency, intensity, and distribution of earthquake activity in an area.

Settlement - The sinking of levee or berm material into the existing land surface caused by compaction of underlying subsurface soils. Settlement is caused by an increase in the weight of overlying levee fill or berms or by pressure resulting from earth movements.

Stage - The height of the surface of a river above an arbitrary zero point.

Subsidence - The lowering of the land surface near levees. Subsidence results primarily from organic peat soil being converted into a gas. Many Delta islands, especially in the western Delta, are composed of peat soils that decompose when exposed to oxygen and higher temperatures (BDOC 1993). The decomposition process is natural but can be accelerated by agricultural tillage activities that expose a greater surface area of peat soils to oxygen over the same period than nontillage.

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CALFED BAY-DELTA PROGRAM
ENVIRONMENTAL IMPACTS/CONSEQUENCES
Technical Report
Flood Control System
September 3, 1997 Draft

1.0 INTRODUCTION

The intent of the CALFED Bay-Delta Program (Program) is to develop long-term solutions to problems affecting the San Francisco Bay/Sacramento-San Joaquin Delta Estuary in Northern California. Overall, the effect of the Program is expected to be beneficial. However, specific Program components may have potentially adverse impacts.

The purpose of this technical report is to document, in a programmatic manner, the potential impacts of the Program on the flood control system that could result from the No-Action Alternative or implementing any of the three Program alternatives. It includes discussions of impacts associated with flood management operations and levee systems. This report discusses potential impacts that may occur in the five regions within the study area, including the Delta Region, Bay Region, Sacramento River Region, San Joaquin River Region, and the State Water Project (SWP) and Central Valley Project (CVP) service areas. The report also contains a brief description of potential mitigation strategies designed to reduce Program impacts to a less than significant level.

Section 2.0 provides an executive summary that will be used in conjunction with other information, data, and the modeling performed during pre-feasibility to prepare the environmental impact sections of the Programmatic EIR/EIS. Following the summary of impacts, Section 3.0 describes the assessment methods. Significance criteria used to evaluate impacts are discussed in Section 4.0. Impacts are discussed in Section 5.0 and references are provided in Section 6.0.

Figure 1 illustrates levee features that are used throughout this report.

2.0 EXECUTIVE SUMMARY

2.1 Summary of Potential Significant Impacts

Potentially significant impacts of the proposed alternatives on the flood control system include:

- Increased flooding upstream of planned flow and stage control structures in the south Delta.
- Increased flooding east of the open channel isolated facility if its design impedes stormwater or flood flow runoff.

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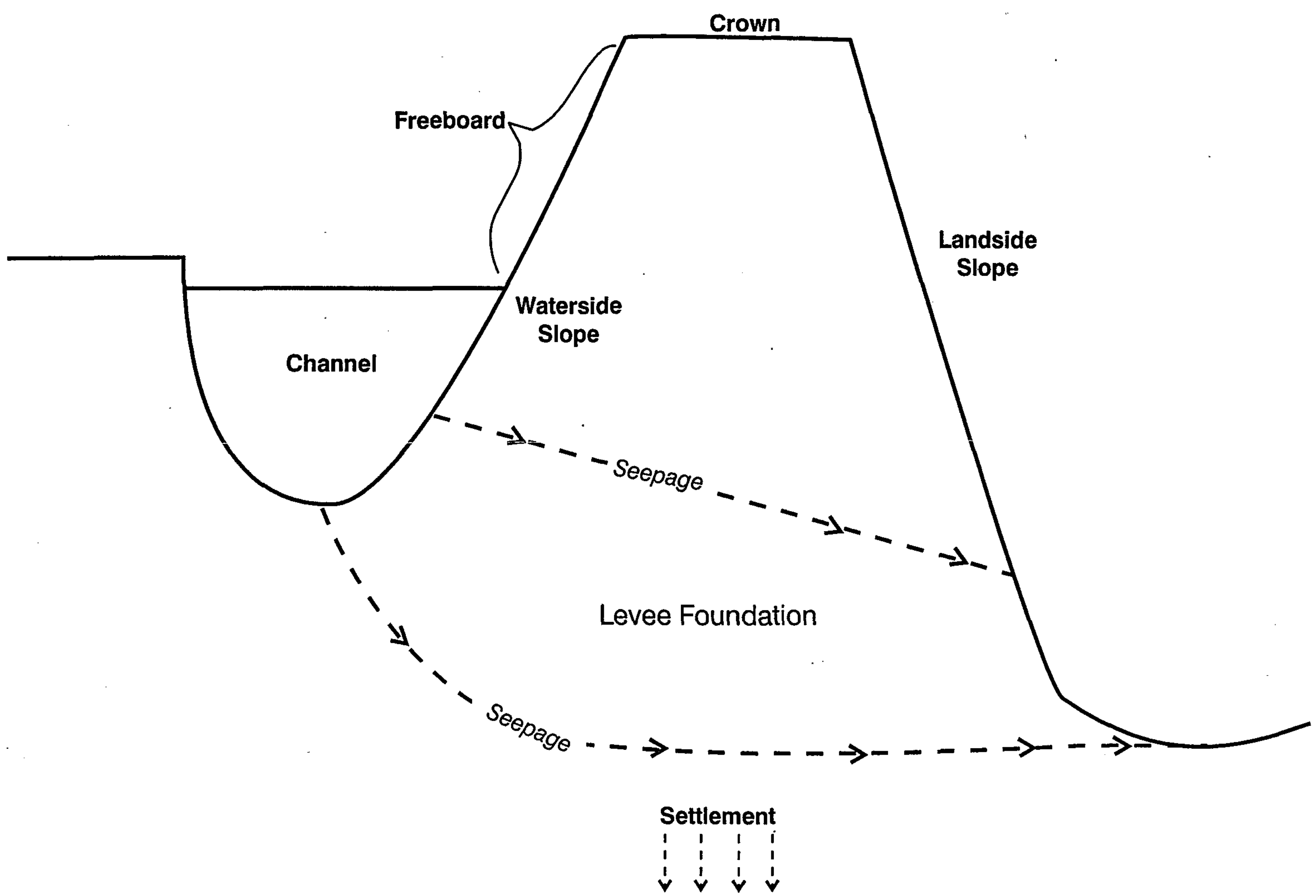

Figure 1 - Levee Features

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- Increased flood stages downstream of the diversion facilities on Sacramento River tributaries if the facilities are removed. The relative impact would probably be largest for small floods and smaller for large floods.

- Increased flood stages along sections of Sacramento River tributaries due to vegetating streambanks, thereby increasing channel roughness.

- Increased flood stages along sections of San Joaquin River tributaries due to vegetating streambanks, thereby increasing channel roughness.

- Reduced levee inspection, maintenance, repair, and emergency response capabilities due to reduced vegetation management.

- Reduced levee stability caused by deep-rooted shrubs and trees established as part of riparian habitat restoration actions.

- Increased seepage adjacent to flooded islands.

- Increased wind-generated wave erosion due to island flooding.

There are no potential significant unmitigable impacts to flood management.

2.2 Summary of Potential Mitigation Strategies

All of the potential significant impacts could be mitigated. Example strategies could include widening stream channels where vegetation or riparian habitats are created and minimizing any obstructions to flow (such as piers or low overhead structures).

2.3 Summary of Potential Significant Unavoidable Impacts

The are no significant unavoidable impacts to the flood management-levee system.

3.0 ASSESSMENT METHODS

The discussion of assessment methods is separated into two sections: flood management operations and levee systems. The flood management operations discussion focuses on the flood control system's ability to handle flood flows under the project alternatives from a conveyance and storage perspective. The analysis of the levee system focuses on the system's ability to handle the flood flows from a structural perspective.

3.1 Flood Management Operations

In order to understand the method used for assessing flood management operations impacts, a brief review of the relationship between Program alternatives, common programs, and actions is needed.

CALFED has developed three alternatives. Each alternative is comprised of the following four "common" programs:

- Ecosystem Restoration
- Water Quality
- Water Use Efficiency, and
- Levee System Integrity.

Each common program is comprised of a set of specific actions designed to achieve certain goals and objectives. Actions comprising a "common" program could generally be implemented in the same manner at the programmatic level for each of the alternatives.

In addition to the four common programs, each alternative contains a combination of storage and conveyance actions. In order to analyze a reasonable range of these combinations, variations of each alternative are considered in this report.

To make the analysis of each alternative more easily understood, operations (i.e., storage and conveyance) actions were analyzed separately. This type of analysis may overlook or minimize some synergistic effects that may occur between actions, but does provide a consistent basis of comparison between alternatives for variable storage and conveyance actions.

Ideally, to compare the flood impacts of each alternative, various size floods (e.g. the 50-year, 100-year, 200-year flood, etc) would be simulated using a hydraulic model of the Delta and tributary areas. The model would predict water surface elevations, flows, and velocities resulting from each alternative. Predictions from one alternative could then be compared to: 1) predictions from another alternative, and 2) a "base case" (e.g., existing conditions). These individual comparisons would allow a quantitative comparison between flooding effects occurring under each alternative, and between any one alternative and the base case.

Since no hydraulic model results were available for this draft report, a different method was used to compare alternatives. For those Program actions that generally involve north Delta modifications, the North Delta Program EIR/EIS (DWR 1990) was reviewed. Flows and elevations from the 1984 flood and a predicted 100-year flood were analyzed. For the south Delta modifications, the Interim South Delta Program (ISDP) EIR/EIS (Entrix 1996) was reviewed.

To further provide a measure of the relative flood control importance of Program actions, data on large flood events in the Sacramento and the San Joaquin rivers were used. For the Sacramento River, daily flow data from the flood of February 1986 were used (Hydrodata, 1997). For the San Joaquin River, daily flow data from the floods of 1980, 1983, and 1997 were used (Hydrodata, 1997). For each alternative, proposed additions to storage were compared to the measured flood flows for these large events. These comparisons were then used to determine if the additional storage proposed for each alternative would substantially increase flood management capabilities relative to expected flood flows.

Simulated changes in conveyance capacity resulting from channel widening were analyzed using the U.S. Army Corps of Engineers (USACE) HEC-RAS model (U.S. Army Corps of Engineers, 1995). This model simulates water surface elevations for a given channel geometry and flow rate. Using this model, different channel configurations in the alternatives could be compared to the base case to determine if these configurations would significantly change conveyance capacity in the potentially affected channels.

3.2 Levee System

Potential impacts to the levee system were assessed using the best available information. The best available information included cited and referenced commercial and scientific literature, and interviews with geotechnical specialists consulted at meetings. These meetings were used to develop the existing conditions and No-Action Alternative trends, and to identify potential impacts and mitigation strategies. Meetings were attended by representatives of the California Department of Water Resources (DWR), United States Department of the Interior, Bureau of Reclamation (Reclamation), the USACE, United States Department of the Interior, Fish and Wildlife Service (Fish & Wildlife Service), and others.

4.0 SIGNIFICANCE CRITERIA

According to the CEQA guidelines, "Significant effect on the environment" means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project, including land, air, water, minerals, flora, fauna, ambient noise and objects of historic or aesthetic significance"(Cal. Code Regs. Title 14, Section (§) 15382 (1995)). Appendix G of the CEQA guidelines states that a project will normally have a significant effect on the environment if it will cause substantial flooding, erosion, or siltation (Cal. Code Regs. Title 14, Appendix G(q)(1995)), or interfere with emergency response plans or emergency evacuation plans (Cal. Code Regs. Title 14, Appendix G(z)(1995)).

The Council on Environmental Quality's implementing regulations for NEPA require consideration of both context and intensity when determining the significance of an impact (40 C.F.R. Part 1508.27). Significance varies with the setting of a proposed action (40 C.F.R. Part 1508.27(a)(1978)).

This programmatic report uses a regional context. Intensity refers to the severity of an impact, and, with respect to flood management systems, includes consideration of:

- both beneficial and adverse impacts (40 C.F.R. Part 1508.27(b)(1)),
- the degree to which the action may affect public health and safety (40 C.F.R. Part 1508.27(b)(2)),
- the degree to which the effects on the quality of the human environment are likely to be highly controversial (40 C.F.R. Part 1508.27(b)(4)),
- the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks (40 C.F.R. Part 1508.27(b)(5)),
- the degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration (40 C.F.R. Part 1508.27(b)(6)),
- whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment (40 C.F.R. Part 1508.27(b)(10)).

4.1 Flood Management System

The description of flood management system impacts are qualitative in nature because of the general level of definition of the programmatic alternatives. Since this evaluation is still at the programmatic stage, an impact on flood management system operations is considered significant if it has the potential to either: 1) raise flood stage elevations, or 2) increase the frequency of flooding. Actions are considered to have less than significant impacts on flood management system operations if they do not substantially raise flood stage elevations, or increase the frequency of flooding.

4.2 Levee System

An action is considered to have a potential significant adverse impact on the levee system if it would substantially increase:

- seepage,
- island subsidence,
- levee settlement,
- wind erosion,
- flood stage hazards (i.e., reduce freeboard),
- scour, or
- sedimentation.

An action is also considered to have a potential significant adverse impact on the levee system if it would substantially decrease:

- levee stability,
- inspection, maintenance, or repair capabilities,
- levee slope protection,
- emergency response capabilities,
- channel capacity, or
- the ability of levees to withstand seismic loading,

Mitigation strategies are recommended for potentially significant adverse impacts.

5.0 ENVIRONMENTAL IMPACTS

5.1 Description of No-Action Resource Conditions

The No-Action Alternative represents the most likely condition of the flood control system in the year 2020 without any of the Program actions. These conditions are not expected to be substantially different from existing conditions. This analysis also assumes that existing SWP and CVP operational criteria and required flood management policies would remain in effect through the year 2020.

There are several projects in various stages of study, planning, and implementation that could possibly affect future conditions under the No-Action Alternative. CALFED staff have worked with agencies, stakeholders, and the public to develop an agreed upon set of projects to be included in the No-Action Alternative. The criteria used for selecting these projects were:

- Has the project been approved?
- Does the project have funding?
- Does the project have final environmental permits and approvals?
- Will the project be excluded from the CALFED actions?
- Would the effects of the project be

identifiable at the level of detail being considered for CALFED analysis?

If a "yes" answer could be provided for any one of the questions, the project was included in the No Action Alternative. **Table 1** lists the projects included in the No Action Alternative.

Table 1
Projects Included in
No-Action Alternative

- Kesterson Reservoir Cleanup
- Coastal Aqueduct
- Shasta Temperature Control Device
- Kern Water Bank (Phases Already Completed or under Construction)
- Spring Creek Toxicity Program
- Sacramento-San Joaquin Delta Levees Project
- Stone Lakes National Wildlife Refuge
- CVPIA (800,000 AF/Year Dedication and Level 4 to Refuges)
- Cache Creek Basin Improvements
- Interim Reoperation of Folsom Reservoir
- Sacramento River Flood Control System Evaluation (Partial)
- Los Vaqueros Reservoir Project
- West Sacramento Project

5.1.1 Delta Region - Resource Conditions

Under the No Action Alternative, continued deterioration of the levees and, hence, diminished ability to handle flood flows is expected. Existing funding, physical, and environmental trends are expected to continue affecting the levee system in the future under the No-Action Alternative.

Funding Trends

Maintenance of the flood control system remains an ever-present challenge. As with other public infrastructure, funding is inadequate to eliminate the maintenance backlog.

The Delta Flood Protection Fund could be extended to authorize about $12 million annually to support the Delta Levees Subventions Program (Cal. Water Code § 12300). Current participation in the program exceeds available funding. Future participation is also expected to exceed funding. Allocations — the actual money spent for local assistance — could be less than authorized. Cost-sharing participants could continue to bear more than their legislated share of levee repair costs (Cal. Water Code § 12585).

The recent enactment of Assembly Bill 360 (Cal. Water Code §§ 12980-12995) extended eligibility to project levees, and Senate Bill 900 (Cal Water Code § 78540-78545) allotted one-time funding of $25,000,000 for the implementation of AB 360 until July 1, 2006. However, new bond revenues could be needed for additional work in the future. As project levee interests' participation continues to exceed available funding, competition for such funding would probably increase.

The inability to compete for limited funding could cause some participants to delay or forego paying for levee repairs. As more participants delay repairs, more levees could deteriorate, resulting in decreases in overall system stability and integrity. It is likely that some islands having less valuable resources could not be reclaimed if they become flooded due to levee failures.

Much of the immediately foreseeable levee improvement funding is expected to be spent for levee stability and habitat improvements to protect valuable economic, water quality, and habitat resources. Some of this immediate funding could be used on western Delta islands that DWR considers important for protecting valuable resources. Levees surrounding western Delta islands protect major Delta channels in the area where fresh and salt waters mix. Levee failure and island flooding could result in undesirable salt water intrusion and other adverse water quality impacts.

In other locations, funding could be adequate to improve existing levees, or to construct new ones. For example, levee assessments and funding may increase in areas where urbanization rates continue to grow. Levees that have been: 1) maintained to the Public Law (PL) 84-99 criteria and performance standards; and 2) approved prior to a flood that has been declared a national disaster, could be eligible for federal funds as part of cost-sharing for post-flood assistance.

The actual locations where funds are expended for flood management system maintenance and improvements depend on future State and Federal policies and priorities regarding relative values of Delta resources. These policies and priorities will require balancing Delta community, ecosystem, economic, land use, infrastructure, water supply, and water quality resource values as limited funds are apportioned to for levee improvement and maintenance work.

Physical Trends

Physical processes cause gradual deterioration of levees and/or increased pressures on the levees. These include subsidence and settlement, erosion from waves and current scour, and internal levee and foundation erosion. All of these processes can lead to an increased risk of levee overtopping and stability failures, especially during flood events.

Island subsidence due to peat oxidation increases the effective height of levees and the water pressure on the levees. As subsidence continues under the No Action Alternative, the ability of the system to handle peak flows will be increasingly jeopardized. Long-term settlement of levees due to ongoing consolidation or migration of foundation soils, especially peat, reduces the levees' crest elevation and therefore the freeboard. Scour and erosion cause loss of levee material. If supporting material is lost at the base, or water-side "toe" of a levee side slope, stability failures could result. Internal erosion, frequently exacerbated by pipes created by animal burrows and decaying tree roots, can also lead to instability or overtopping.

There were 27 recorded Delta levee failures from 1967 to 1992 (DWR 1993). Twenty-six of these failures occurred during major floods. About half resulted from overtopping, and half from stability failures.

Delta dredging is limited to 45 days - August 1 to September 15 - during the summer because of regulatory constraints and species considerations, making the Delta a limited source of dredged borrow material. Future Delta dredging is assumed to be limited to short summer periods because of regulatory requirements.

Environmental Trends

Coordinated habitat restoration efforts will probably continue. Senate Bill (SB) 1065, enacted in 1991 (Cal. Water Code § 12306, 12307), required habitat protection as part of levee maintenance work. Senate Bill 1065 directed future mitigation associated with levee maintenance to result in no net long-term loss of habitat. California Water Code Section 12987(c) states that the California Department of Fish and Game shall not approve any levee maintenance or improvement plans which will result in a net long-term loss of riparian, fisheries, or wildlife habitat.

The CALFED Environmental Restoration Program Plan (ERPP) is a long-term habitat restoration program. Habitat restoration could encourage vegetation on levee slopes, and root invasion and burrowing by rodents. Root holes and burrows could allow water to penetrate the levees, resulting in reduced levee stability. Vegetation would also make levee inspection more difficult.

Urbanization pressures from the perimeter of the Delta Region could continue. Residents and users of new developments could accelerate levee deterioration through increased access, boat-wake induced erosion, and vandalism (e.g. unauthorized recreational driving on levee slopes, disturbance or removal of rock protection, etc.). As urbanization continues in and around the Delta and its contributing streams and rivers, runoff is expected to increase. Increasing runoff could lead to increased stage in the Delta.

5.1.2 Bay Region - Resource Conditions

Flood control resources are, with few exceptions, located upstream of the Bay Region. Their principal effect on the Bay Region is the timing and magnitude of fresh water flows discussed in the Hydrodynamics and Water Quality Technical Reports.

5.1.3 Sacramento River Region - Resource Conditions

The Sacramento River Region contains a wide range of flood control resources including levees, weirs, bypasses, and reservoirs. Weirs and bypasses are covered by Federal and State agreements. These facilities would continue to operate under the No-Action Alternative the same as they do today. Likewise, the reservoirs are covered under a variety of Federal, State, and cooperative agreements which ensure that they too will operate effectively through 2020.

The majority of the levees are part of State and Federal programs. Under the No-Action Alternative, current maintenance and repair policies are assumed to continue through the year 2020. With this assumption, the levees can be expected to perform adequately through the year 2020. This is not to suggest that failures will not occur during the period, but that the failures will be due to the vagaries of nature and that performance will not differ substantially from the existing condition.

The levees in the Sacramento River region are subjected to three forces that affect their performance: overtopping, seepage, and erosion. In general, these forces can be handled through the currently authorized maintenance and emergency response mechanisms.

5.1.4 San Joaquin River Region - Resource Conditions

The reservoirs operated for flood control in the San Joaquin River region are again covered under a variety of State, Federal, and cooperative agreements. Through the year 2020, this system would continue to operate as it does today.

Under the No Action Alternative, the same three potential failure causes affecting levees and bypasses in the Sacramento River Region affect the San Joaquin River Region: overtopping, seepage, and erosion. The levees and bypasses covered under the State and Federal project authorizations will continue to function effectively through 2020. As with the Sacramento River Region, this does not mean that levee breaks and problems will not occur, but rather that the system will function as it does today with maintenance and emergency response mechanisms handling problems as they occur. Private levees, as the recent flooding of 1997 showed, have demonstrated variable performance depending on a wide variety of factors including construction standards, length and duration of storm, and location.

5.1.5 SWP and CVP Service Areas Outside of the Central Valley - Resource Conditions

The performance of the flood control resource under the No-Action Alternative could have an adverse effect on the SWP and CVP service areas outside the Central Valley. As discussed above, the flood control system in the Delta could continue to deteriorate under the No-Action Alternative. Depending, on the actual circumstances, deterioration of the floodway, which is also the conveyance for water to SWP and CVP facilities, could reduce or interrupt the quantity and/or quality of water supplied outside the Central Valley.

5.2 Description of Alternative Resource Conditions

Alternatives 1, 2 and 3 are discussed below. Each alternative consists of two primary components: "Common Program" and "Alternative Specific Storage and Conveyance Program." They differ from each other primarily in regard to the actions taken to modify conveyance and water storage facilities. The impacts of each alternative on the flood control system are discussed below.

5.2.1 Delta Region

5.2.1.1 Alternative 1

In addition to the Common Program, Alternative 1 includes three proposed configurations for south Delta modifications. The impacts of these modifications on the flood control system are discussed following the Common Program discussion.

Common Program Impacts

Ecosystem Restoration Program. Within the Delta Region the Ecosystem Restoration Program consists of 22 resource elements,

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each with one to five specific action items. The programmatic resource elements, and actions are listed in Appendix Table A-1, and were based upon the Phase II Alternative Descriptions Report (CALFED 1997). The resource elements were screened and the following were identified as actions that could significantly impact flood management operations and capabilities:

- Delta Channel Hydraulics,
- Floodplain Inundation and Sediment Detention, and
- Riparian Scrub Habitat.

Impact 1-1 (Beneficial). *Increased channel capacity as a result of setback levee construction.* The construction of new setback levees under the Ecosystem Restoration Program to increase the conveyance of selected Delta channels would have a beneficial impact relative to the No Action Alternative (Figure 2). Table 2 presents an example of the impacts of setback levees on flood control. The capacity of three example channel sizes, 50-foot, 100-foot and 300-foot bottom widths were estimated with and without setback levees. Table 2 generally indicates that the impacts are greatest for smaller channels.

Impact 1-2 (Beneficial). *Reduced peak flood flows downstream of overflow basins.* The construction of overflow basins and conversion of leveed lands to wetlands under Resource 4 would reduce peak flood flows to areas downstream of the overflow basins. The sizes of the overflow basins have not yet been determined; therefore, the reduction in flood flows cannot be estimated.

However, given the flood sizes that have occurred in the north Delta, the impacts to the flood control system are expected to be small or localized unless a large number and acreage of the Delta islands are made available for flood storage. For example, during the flood of February 1986, almost 4 million acre-feet of water was recorded passing Freeport in the Sacramento River. Over 1 million acre-feet of flow passed Freeport during the five highest flow days (February 17 through 21). To significantly reduce these flows would require converting many of Delta islands located along the Sacramento River to overflow basins.

Impact 1-3 (Beneficial). *Increased channel capacity due to widening and establishing floodplain areas along Delta channels.*

Table 2
Estimated Increase in Channel Capacity with 100-foot Setback Levee[1]

Channel Bottom Width	To Top of Levee	With 3-foot Freeboard
50	40%	16%
100	25%	4%
300	1%	0%

[1] 10-foot deep channel with 10 foot levees (20 foot depth from channel bottom to top of levee). Setback levee 100-feet on one side of channel.

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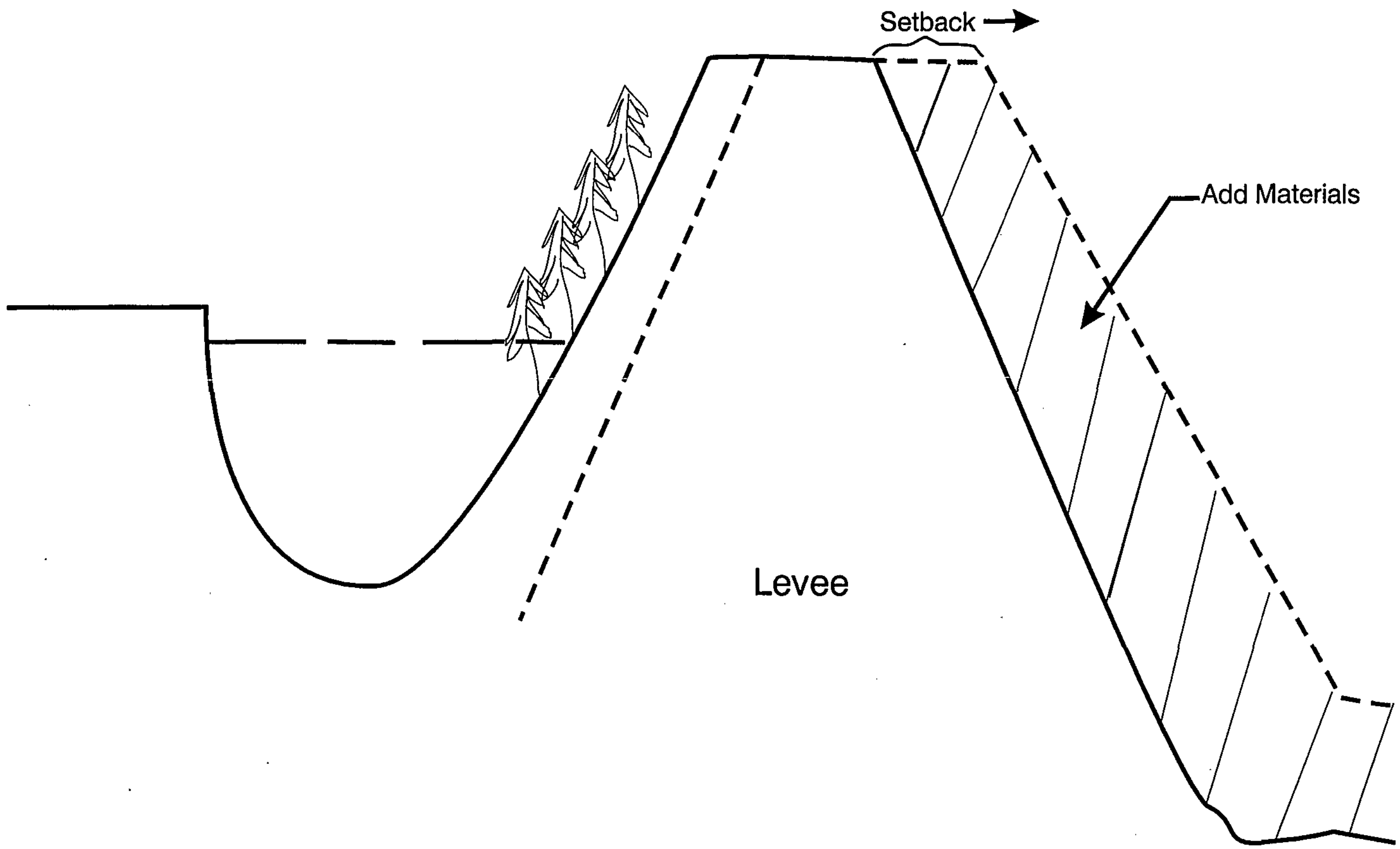

Figure 2 - Partial
Setback Levee

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Widening and or providing floodplain areas along Delta channels would have a beneficial impact on the flood control system. The impacts to flood control of restoring riparian corridors would be similar to those described for setback levees. The relative impacts would be minor on large channels and more significant on small channels.

Impact 1-4 (Adverse). *Reduced Levee Inspection, Maintenance, Repair, and Emergency Response Capabilities Due to Reduced Vegetation Management.* Reduced levee and berm vegetation management practices may result in significant and adverse long-term impacts to levee stability. Reduced pruning and clearing would allow more deep-roots to penetrate levees, and more dense vegetative canopies on levee surfaces. Dense vegetation could substantially reduce inspection capabilities by hiding rodent holes, cracks, or other potential causes of levee degradation. Thick understory vegetation would also limit access to levees, thereby reducing maintenance, repair, and emergency response capabilities.

Mitigation Strategy. Allow reasonable clearing of deep-rooted trees and shrubs from levees to support inspection, maintenance, repair, and emergency response. Implementation and mitigation monitoring could reduce this impact to a less than significant level.

Impact 1-5 (Beneficial). *Increased Erosion Protection.* Increased density of shallow-rooted grasses and vegetation could beneficially increase erosion protection on levee side slopes. Shallow roots protect levees against erosion by binding soil particles.

Impact 1-6 (Adverse). *Reduced levee stability caused by deep-rooted shrubs and trees established as part of the habitat restoration actions.* Habitat restoration using conservation easements along riparian corridors could significantly and adversely reduce levee stability. Over time, deep-rooted and dense riparian trees and shrubs could increase the opportunity for roots to penetrate levees. Root activity could reduce levee stability. Increased cracking and fissures could allow water to enter the levee interior, resulting in reduced structural stability. Small cracks, fissures, and root voids could also allow increased seepage beneath the levee, which could increase levee instability.

Mitigation Strategy. Allow clearing of deep-rooted shrubs and trees on levees. Allow trees and shrubs to grow only on adjacent berms. If roots are allowed to penetrate levees, add fill materials to levee landside slopes to construct a partial setback levee and increase stability. Implementation and mitigation monitoring could reduce this impact to a less than significant level.

Impact 1-7 (Adverse). *Increased seepage due to shallow flooding.* Shallow flooding of central and western Delta islands susceptible to subsidence could significantly and adversely increase seepage, reduce the stability of adjacent levees, and cause substantial flooding due to seepage-induced failure. Water seeping beneath levees contributes levee instability. Sandy levees are especially susceptible to seepage erosion and the resulting formation of "pipes" or large voids in the levee material (Bay-Delta Oversight Council (BDOC) 1993). The amount of seepage could depend on soil permeability, seepage path length under the levee, and the height of the hydraulic head.

Mitigation Strategy. Identify locations potentially susceptible to seepage-induced failure on Delta islands that may be intentionally flooded. Implement a seepage monitoring program on non-flooded islands adjacent to potential shallow-flooded islands. Develop seepage control performance standards to be used during island flooding and storage periods to determine net seepage caused by shallow flooding. Improve levees to withstand expected hydraulic stresses and seepage. Implementation and mitigation monitoring could reduce this impact to a less than significant level.

Impact 1-8 (Adverse). *Wind-generated wave erosion due to island flooding.* Island flooding could result in significant increases in wind-fetch and wave erosion on waterside levee slopes. Long fetches created by the flooded areas would result in larger wave generation that could substantially erode levee slopes. This is may be a gradual problem whose impacts may not be detected until there has been significant removal of levee slope material by wind-generated wave erosion.

Mitigation Strategy. Design erosion protection measures to minimize or eliminate wave splash and run-up erosion. Use riprap or another suitable means of slope protection to dissipate wave force. Large voids in the riprap relieve excess hydrostatic pressures caused by waves washing against the slope (DWR 1990). Construction of large wind/wave breaks within the flooded islands would reduce wind-fetch and erosion potential. Implementation and mitigation monitoring could reduce this impact to a less than significant level.

Water Quality Program. Actions to reduce pollutant loading from mine drainage, agricultural drainage, urban and industrial runoff, and municipal and industrial wastewater treatment facilities to the Delta and its tributaries are included in the Water Quality Program. No actions under this program would affect the flood control system. Source control, treatment, management, and intake relocations would not increase the chance for flooding, erosion, seepage, subsidence, settlement, scour, or sedimentation. These actions would not reduce levee stability, inspection, maintenance, or repair capabilities, slope protection, emergency response capabilities, or channel capacity.

Water Use Efficiency Program. The purpose of the Water Use Efficiency Program is to ensure that California's water supplies are used efficiently. No action items in the Water Use Efficiency Program would impact the flood control system. This set of options are primarily concerned with policy, not technical issues; most of these actions would be implemented by local agencies rather than CALFED agencies. Implementation of this program would not increase the chance for flooding, erosion, seepage, subsidence, settlement, scour, or sedimentation. These actions would not reduce levee stability, inspection, maintenance, or repair capabilities, slope protection, emergency response capabilities, or channel capacity.

Levee System Integrity Program. The Delta Levee System Integrity Common Program focuses on providing long-term protection for Delta resources by maintaining and improving the integrity of the Delta levee system. Another objective of this common program is to integrate ecosystem restoration and levee improvements. Some system vulnerability problems and the actions needed to correct them are well understood, while other such problems require more research. Implementation of this common program will require reliable, long-term funding that distributes the costs of assuring levee system integrity among all beneficiaries.

The Delta Levee System Integrity Common Program has five elements, including the:

- Delta Levee Base Level Protection Plan,
- Delta Levee Special Improvement Projects
- Delta Island Subsidence Control Plan
- Delta Levee Emergency Management Plan, and
- Delta Levee Seismic Risk Assessment.

Program staff would work with other agencies and stakeholders to identify deficiencies in existing programs, and measures to address them. These measures would be integrated with the Ecosystem Restoration Program Plan and Delta conveyance actions. Each element is summarized below.

The Delta Levee Base Level Protection Plan strives to use existing programs to increase the extent of Delta project and nonproject levees that meet minimum federal flood control performance criteria. Local reclamation districts would provide the primary source of resources for maintaining and improving the Delta levee system, with increased State and Federal participation and resources. Policy-related actions might include definition of minimum levee maintenance requirements, minimum levee improvement design criteria, ongoing levee maintenance and improvement funding requirements, State-Federal-local cost sharing plans, and a phasing sequence for all common program actions. Physical actions with the potential to improve the levee system might include seepage and erosion control, levee stability improvements, and flood conveyance improvements.

The Delta Levee Special Improvement Projects provide increased flood protection beyond the Delta Levee Base Level Protection Plan for Delta islands with many public benefits. Overall priorities for planning levee improvements will be based on a ranking of how well levees or islands protect one or more of the water quality, agricultural production, life and personal property, cultural resources, recreation, the ecosystem, or infrastructure functions. Physical actions with the potential to improve the levee system might include increasing levee stability and improving flood conveyance conditions.

The Delta Island Subsidence Control Plan promotes island subsidence to provide long-term reliability of Delta levees in coordination with other agencies and stakeholders. Evaluations of subsidence rates and depths of organic soils will be included in an implementation plan that will identify actions and a phasing sequence for correcting subsidence. Research-related actions might include investigations of the effects of agricultural practices on subsidence and projects demonstrating subsidence control or reduction practices.

The Delta Levee Emergency Management Plan will build upon existing emergency management resources to protect critical Delta resources during an emergency. Program staff will coordinate emergency planning with other State, Federal, and local agencies and stakeholders to identify pre-emergency and post-disaster recovery measures, including planning and allocation resources prior to an emergency, developing levee repair and recovery effort criteria, and planning and allocating resources for recovery efforts.

The Delta Levee Seismic Risk Assessment will identify and increase the understanding of the seismic risks to Delta resources and develop recommendations for increasing Delta levee seismic stability. Program staff will use existing and new sesimic information to identify important seismic issues and improve risk reduction planning and coordination with other agencies and stakeholders. Actions designed to improve seismic risk information might include updating seismic risk information, evaluating Delta levee seismic performance, and identifying cost-effective measures to improve the stability of Delta levees.

Storage and Conveyance Facilities Impacts

Alternative 1A

Storage. No new water storage facilities are included in Alternative 1A.

Conveyance Facilities. No conveyance improvements are included in Alternative 1A.

Alternative 1B Storage and Conveyance Facilities Impacts

Storage. No new water storage facilities are included in Alternative 1B.

Conveyance Facilities. Modifications are proposed in the south Delta that would reduce the current impact of the CVP and SWP export operations. These improvements include:

- Installing an operable barrier or equivalent at the head of Old River to maintain a positive flow in the San Joaquin River.
- Installing flow and stage control measures in the Middle River, Grant Line Canal, and Old River or other methods to control flow, stage, and south Delta salinity.
- Installing new fish screens at the Skinner Fish facility and at the Tracy Pumping Plant intake.
- Installing an intertie between Tracy Pumping Plant and Clifton Court Forebay.

The new fish screens and intertie are not expected to have significant impacts on flood management.

Impact 9 (Adverse). *Reduced flood flow conveyance due to gate structures located in channels.* The interim operable barrier at the head of the Old River and the control structures on Middle River, Grant Line Canal and Old River are similar to the alternatives described in the Interim South Delta

Program (ISDP) EIR/EIS. These controls would not be operated during periods of high flow in the San Joaquin River. However, the gate structures located within these channels could reduce their flood flow conveyance, resulting in increased stage upstream of the structures and possibly decreased stage downstream. The amount of increase (or decrease) would depend upon the final design of the structures and could be mitigated accordingly.

Mitigation Stategy. These impacts could be mitigated if the structures are designed to minimize the loss of channel conveyance at the structure.

Alternative 1C

Alternative 1C would add new storage and conveyance facilities to Alternative 1B, including enlargement of Delta channels.

Storage. New storage facilities would potentially be constructed outside of the Delta. These include:

- 3 million acre-feet of surface water storage upstream of the Delta in the Sacramento Valley.
- One million acre-feet of surface water storage off-aqueduct (south of the Delta).
- 500,000 acre-feet of groundwater storage in the Sacramento Valley.
- 500,000 acre-feet of groundwater storage in the San Joaquin Valley.

Impact 1-10 (Beneficial). *Incidental flood storage.* The only storage option with potential flood impacts in the Delta would be up to 3 million acre-feet of additional surface storage in the Sacramento Valley. Groundwater and off-aqueduct storage would not capture and attenuate stormwater runoff flows significantly and, therefore, would not impact flood flows.

It is assumed for the purpose of this programmatic evaluation that the 3 million acre-feet of additional storage would be equally divided among environmental, agricultural, and water supply. Storage available for flood control would be incidental only (i.e., storage not presently being used for other purposes and was available when a storm occurred). If only a small amount were available for flood control, flooding in the Delta would not be significantly impacted.

To provide a qualitative estimate of the potential benefits to the flood control system in the Delta of this increased storage, flows from the February 1986 storm in the Sacramento Valley were reviewed. Table 3 shows the flow volumes in the Sacramento River and its main tributaries from February 15 to 19(when the peak flow occurred at Freeport.

Each river had flows in excess of 200,000 ac-ft per day during the peak of the flood. Three million acre-feet of additional storage would have only had minor benefit on these tributaries, as the proposed storage is relatively small compared to the daily flow volumes and flood control storage would be incidental to other dedicated uses.

Conveyance. The impacts of the operable barrier and the stage control measures in the south Delta are described under Alternative 1B.

Table 3
Volumes of Flow in the Sacramento River Valley during the February 1986 Storm Event
(volumes in acre-feet)

Date	Upper Sacramento River at Butte City (#11389000)	Feather River near Gridley (#11407150)	Yuba River near Marysville (#11421000)	American River near Fair Oaks (#11446500)	Sacramento Weir Spill to Yolo Bypass (#11426000)	Sacramento River at Freeport (#11447650)
2/15/86	174,942	35,702	18,149	40,066	103	127,140
2/16/86	243,967	64,860	37,488	52,959	1,083	161,653
2/17/86	224,132	128,331	127,140	158,876	98,777	194,579
2/18/86	257,851	251,901	183,868	245,950	195,570	214,215
2/19/86	281,653	289,587	200,331	259,950	241,983	228,099
Total	1,182,545	770,381	566,976	757,801	537,516	925,686

= USGS gaging station number

Each river had flows in excess of 200,000 ac-ft per day during the peak of the flood. Three million acre-feet of additional storage would have only had minor benefit on these tributaries, as the proposed storage is relatively small compared to the daily flow volumes and flood control storage would be incidental to other dedicated uses.

Conveyance. The impacts of the operable barrier and the stage control measures in the south Delta are described under Alternative 1B.

5.2.1.2 Alternative 2

The impacts of Alternative 2 on the flood control system are discussed below. In addition to the Common Program, Alternative 2 includes modifications to Delta conveyance channels and three storage configurations.

Common Program Impacts

The impacts of the Common Program would be similar to those described in Section 5.2.1.1.

Storage and Conveyance Facilities Impacts

Alternative 2A

Storage. No new storage facilities would be planned under Alternative 2A.

Conveyance Facilities. Improvements in conveyance would be provided between the Sacramento and Mokelumne rivers along Snodgrass Slough. The conveyance of the Mokelumne River from I-5 to the San Joaquin River would be increased by setting back the existing levees on one side of the channel by 500 feet.

This alternative is similar to the preferred alternative analyzed in the North Delta Program EIR/EIS (DWR, 1990). In addition to setting back the levees 500 feet along one side of the North Mokelumne, the North Delta Program alternative also included channel enlargements. The North Delta Program alternative would result in significant reductions in the 100-year flood stages throughout the north-Delta area. The North Delta Program EIR/EIS analysis included simulated levee breaks. Reductions in the 100-year stage varied from about 2.9 to 4.5 feet at New Hope Landing with decreasing impacts moving downstream. At the confluence of the North and South Forks of the Mokelumne River no difference was predicted.

Impact 2-1 (Beneficial). *Reduced flood stage due to levee setback on the Mokelumne River.* A HEC-RAS model of the Mokelumne River using flow and cross-section data from the North Delta EIR/EIS was used to determine if levee setbacks alone would result in the benefits obtained with the North Delta Improvements. The HEC-RAS results indicate that about half of the reduction in flood stage reported in the North Delta Program EIR/EIS is due to the levee setback and about half is due to the dredging of the North Fork Mokelumne River. Therefore, based on these HEC-RAS results and the North Delta EIR/EIS model results, the 100-year flood stage is expected to be reduced by about 1 to 2 feet near the McCormack-Williamson Tract due to the proposed levee setback alone. At the confluence of the North and South Forks of the Mokelumne River, the North Delta Program assumed no significant reduction in flood stages. The same would be true for this alternative.

Impact 2-2 (Beneficial). *Increased conveyance capacity on Old River.* South Delta modifications include channel enlargement along a 4.9-mile reach in Old River, an operable barrier at the head of Old River, and flow and stage control on Middle River, Grant Line Canal and Old River. These are similar to the alternatives described in the ISDP.

Enlargement of the Old River channel would increase the conveyance capacity of this channel. This could result in some localized reductions in flooding. The impacts of the flow and stage control structures were discussed under Alternatives 1B.

Alternative 2B

Storage. Alternative 2B would add new storage facilities to Alternative 2A. The new storage facilities are the same as those described in Alternative 1C, with the addition of 500,000-acre feet of surface water storage upstream of the Delta on San Joaquin tributaries and an increase in off-aqueduct storage of from 1 to 2 million acre-feet. The increase in off-aqueduct storage would have no impact on flood flows in the Delta.

Impact 2-3 (Beneficial). *Increased flood storage.* Flow data at Vernalis and Gravelly Ford on the San Joaquin River for the storm that occurred from December 1996 to January 1997 were reviewed to quantitatively estimate the impacts on flood control of an additional 500,000 acre-feet of storage even though the additional storage would not be designated for flood control, but for environmental, urban, and agricultural purposes. During the peak of this storm (from January 3 through 6) about 130,000 acre-feet of water was released from Millerton Reservoir, which reached its peak storage and inflow on January 3. If over about 100,000 acre-feet of additional storage had been available, a significant reduction in flood flows downstream of Millerton Reservoir could have occurred. Therefore, if a significant percentage of the 500,000 acre-feet was available for flood storage on the San Joaquin River, significant flood control benefits could be obtained. However, since the additional storage is not now designated for flood control, it cannot be counted on to be available and the flood benefits may not be realized.

Conveyance Facilities. The impacts of changes in conveyance are the same as those described under Alternative 2A.

Alternative 2C

Storage. No new storage is proposed under this alternative.

Conveyance Facilities. Alternative 2C adds three isolated facilities in the south Delta to better convey water to the Clifton Court Forebay and the Tracy Pumping Plant: a 15,000 cfs intake near Holland Tract, a 5,000 cfs intake at Upper Roberts Island in the San Joaquin River, and a 15,000 cfs intake at the north end of Roberts Island. These pumps may not operate during large storm events in order to protect the intake screens from large debris. In this case, the isolated facilities would not have an impact on flood management. However, operating two of the three facilities during storm events could have beneficial impacts to flood management.

The western 15,000 cfs intake located along the eastern side of Holland Tract would pull water out of a new 50,000 to 100,000 acre-foot storage facility on Holland Tract and/or local Delta channels. This facility would have minimal impacts or flood management along the San Joaquin River since it is located far downstream in the tidally influenced zone of the Delta and far from the river.

***Impact 2-4 (Beneficial)**. Increased channel capacity on the San Joaquin River due to 5,000 cfs intake.* The eastern 5,000 cfs intake located in the San Joaquin River along Upper Roberts Island could provide significant flood control benefits, especially for small flood events. This section of the San Joaquin River has limited capacity at present and a 5,000 cfs intake could provide a relatively large increase in channel capacity. However, for large events, the additional capacity is probably not sufficient to eliminate flooding. For example, during the January 1997 floods along the San Joaquin River the peak flows in the San Joaquin River at Vernalis were about 48,000 cfs or almost 10 times the capacity of the Eastern Intake. This event produced upstream levee breaks; the downsteam flows would have been much higher without the relief provided by levee breaks.

***Impact 2-5 (Beneficial)**. Reduced flood flows due to 15,000 cfs intake.* The northern 15,000 cfs intake would be located along the San Joaquin River at the northern end of Lower Roberts Island in the tidal zone. This intake is large enough to significantly reduce flood flows (assuming that the full capacity of the intake could be utilized during large storm events). Mac Donald Island, Venice Island, Webb Tract and Jones Tract all flooded in either 1980 or 1982. If the flows in the San Joaquin River could be reduced by 15,000 cfs or more during large storm events, the occurrence of island flooding could be reduced. Peak daily flows at Vernalis during the 1980 flood averaged about 20,000 to 25,000 cfs during February and March with peak daily flows of over 30,000 cfs. During the April 1982 floods, the peak daily flow was almost 30,000 cfs with flows exceeding 20,000 cfs most of the month. If the proposed intakes had been operating and could have efficiently removed the design flows from the San Joaquin River, flows in the sloughs surrounding the islands would have been reduced and some of this flooding may have been avoided.

Alternative 2D

Storage. Up to 2 million acre-feet of off-aqueduct storage is proposed south of the Delta. As discussed earlier (Alternative 2B), off-aqueduct storage would provide little flood control benefit.

Conveyance Facilities. This alternative provides for channel modifications to the South Fork of the Mokelumne River to increase conveyance, setback levees along Old River to increase conveyance to Clifton Court Forebay and construction of an operable fish barrier at the head of Old River. The impacts on flood management of increasing conveyance along Old River and construction of an operable fish barrier were discussed under Alternative 2A. The impacts associated with the setback levees are discussed below.

Impact 2-6 (Beneficial). *Increased floodplain width and reduced stage due to construction of setback levees on the South Fork Mokelumne River.* Alternative 2D includes several sets of setback levees. On the South Fork Mokelumne River these include 2000-foot setbacks to the east onto New Hope and Terminous Tract, and a 4000-foot setback to the west on Staten Island. These setbacks would significantly increase the floodplain width and result in a lower flood stages. In general, the discussion of the effects of 500-foot setback levees in Alternative 2A are also applicable here. However, since these setbacks would be significantly larger, flood water surface elevations are expected to drop further. Given a flow of 34,400 cfs, (the peak flow during the 1986 flood event in the North Fork Mokelumne [1990 North Delta Program EIR/EIS]), the flood stage may drop an additional foot (below the 500-foot setback level) for the 2000-foot setbacks, with an additional one-half foot drop for the 4000-foot setback.

Impact 2-7 (Beneficial). *Increased conveyance capacity and reduced water surface elevations as a result of new flooded habitat.* Portions of levees along the Canal Ranch and Brack Tracts and Bouldin Island would be removed to flood the islands and provide new flooded habitat. Aside from increasing conveyance capacity on the South Fork Mokelumne, the levee setback and levee removal alternatives will lower local water surface elevations and reduce peak flows. Reductions in peak flow rate could be on the order of 5 to 10 percent. Water surface elevations could drop on the order of 2 to 4 feet relative to existing conditions. This effect would also likely propagate a few miles upstream. Levee setbacks and removals would have two additional impacts. Lower water surface elevations would (1) result in a steeper hydraulic gradient and higher flow velocities immediately upstream of the levee removal location (the maximum increase in these velocities is expected to be on the order of 1 to 2 feet per second); and (2) change the flow distribution, possibly increasing the volume of water that discharges through the South Fork.

The impacts of the operable barrier in the south Delta are described under Alternative 1B.

Alternative 2E

Storage. This alternative is similar to Alternative 2D with the addition of (1) increased conveyance along Georgiana Slough from Sacramento River to the weir intake into the central Delta, (2) flooding of Tyler Island, and (3) introduction of storage facilities. As with Alternative 2D, breached levees are expected to significantly reduce flood levels only if they provide flow conveyance as well as storage; and additional storage is not anticipated to provide significant flood benefits. Therefore, the flooding of Tyler Island and McCormack-Williamson Tract, Bouldin Island, and tracts along the eastern side of the South Fork would provide only limited flood control benefits, as they would reduce peak flow rates, but are not expected to significantly lower water surface elevations. For example, the DWOPR modeling of the North Delta (DWR, 1990) indicates that during the 1986 flood, water levels dropped one foot when the Tyler Island levee breached. This was probably the result of the storage in Tyler Island. This storage would not have been available had the Tyler Island levee been breached and flooded before the peak flow rates arrived, as would be the case for the flooded islands in this alternative.

Conveyance Facilities. This alternative is similar to Alternative 2D with the addition of increased conveyance along Georgiana Slough from the Sacramento River weir intake into the central Delta. The setback on Georgiana Slough would not affect flows downstream.

However, changes in conveyance capacity may, impact water surface elevations and flow splits. As with Alternative 2D, the overall effect would be the reduction of peak water surface elevation at and upstream of the levee removal location. The setback on Andrus Levee, coupled with the absence of setbacks on New Hope (and to a lesser extent, Terminous Tract), would alter flow splits between the North and South Forks of the Mokelumne River. When compared to Alternative 2D, Alternative 2E would result in more water flowing to the North Fork and proportionately less to the South Fork Mokelumne River.

The impacts of the operable barrier in the south Delta are described under Alternative 1B.

5.2.1.3 Alternative 3

The impacts of Alternative 3 on the flood control system are discussed below. In addition to the Common Program, Alternative 3 combines the Alternative 2 storage and conveyance options with 3 variations of an isolated facility between the Sacramento River and Clifton Court Forebay.

Common Program Impacts

The impacts of the Common Program would be similar to those described in Section 5.2.1.1.

Storage and Conveyance Facilities Impacts

Alternative 3A

Storage. No new storage facilities would be planned under Alternative 3A.

Conveyance Facilities. This alternative includes conveyance options that are part of the north- and south-Delta modifications described in Alternative 2A. In addition a 5,000 cfs open channel isolated facility from Hood (or Freeport) on the Sacramento River to Clifton Court Forebay, with siphons under all major stream crossings is included. The isolated facility could have two impacts on flood control and management. First, if it was operated during flood events, and removed a significant volume of water from the Sacramento River and efficiently conveyed the water around the Delta, it could reduce the level of flooding downstream. Second, depending upon how the facility is constructed, it could act as a dam to flood flows from the east.

To estimate the impacts of the isolated facility on reducing flood flows in the Sacramento River, the average daily flow data in the Sacramento River at Freeport was analyzed to estimate the flow rates for various return period storm events. These flows were compared to the capacity of the isolated facility to determine its importance in reducing flood flows. Table 4 shows the estimated average daily flows at Freeport for each month for various return periods. The 5,000 cfs removed by the isolated facility is less than 10% of the 10-year return period winter storm events and only about 5% of the 100 year return period events. Therefore, the isolated facility would not have a significant effect on reducing flood flows.

Impact 3-1 (Adverse). Increased flooding east of the proposed isolated facility. The isolated facility runs west of and roughly parallel to Highway 5. For much of its length, the isolated facility would be routed through areas not prone to frequent flooding. However, it would run through New Hope Tract, which flooded in 1986 when a levee on the Mokelumne River failed near Thornton. If the isolated facility was constructed to prevent flood flows into, over, under, or around it (for example if it has levees adjacent to it to prevent the entry of storm water runoff), the facility could act as a dam during similar flooding events. This could cause increased flooding to the east of the facility and lengthen the time needed for pooled water to drain after the flood wave passes.

Mitigation Stategy. If the isolated facility is constructed at or below ground level with no adjacent levees, it would have no impact, or only minor impacts on flooding since flows would be free to flow into or over the facility.

Alternative 3B

Storage. This alternative is the same as Alternative 3A except for the addition of new storage upstream of the Delta in the Sacramento and San Joaquin tributaries, off-aqueduct storage south of the Delta, 200,000 acre-feet in-Delta storage, and increased groundwater storage. The impacts of new storage were discussed in previous alternatives (Alternatives 1C, 2B). The only new storage added in Alternative 3B is the 200,000 acre-feet in-Delta storage.

However, the in-Delta storage is not allocated for flood control. Also, it is small relative to the flood flows that pass through the Delta during a large storm event and therefore is not expected to have a significant impact on flood management.

Alternative 3C

This alternative is identical to Alternative 3A except that the isolated facility would be in a pipeline instead of an open channel. This alternative would not have any additional impacts to flood management not already discussed in Alternative 3A. To the extent that the canal proposed in Alternative 3A may act to dam overland flows, this Alternative would have fewer impacts, because the pipeline would not impede overland flows.

Alternative 3D

This alternative is identical to Alternative 3B except that the isolated facility is in a pipeline. Impacts are discussed in Alternative 3B.

Alternative 3E

This alternative is similar to Alternative 3B except that the isolated facility has a capacity of 15,000 cfs instead of 5,000 cfs, and it does not include the Old River enlargement and barrier.

Impact 3-2 (Beneficial). *Lowered flood flows during relatively small floods.* Withdrawing 15,000 cfs from the Sacramento River could have the effect of lowering flood flows for small floods (10-year and smaller), but would not have a significant effect on large floods (100-year and larger). If the 100-year flood flows downstream of Hood (or Freeport) could be reduced by 15,000 cfs they would be equivalent to about a 20-year event. This would still be large enough to cause considerable flooding under the No-Action Alternative.

Alternative 3F

Storage. This alternative would provide for upstream surface water storage in the Sacramento and San Joaquin River basins, off-aqueduct storage south of the Delta, and additional groundwater storage. The

Table 4
Estimated Daily Average Storm Event Flows (cfs) on the Sacramento River at Freeport (USGS gage # 11447650 (Hydrosphere , 1994))

Return Period (years)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
100	93,000	90,600	83,200	87,100	71,000	54,800	32,400	25,500	27,000	26,200	76,700	90,200	83,200
20	81,600	76,900	74,400	70,500	58,700	41,800	22,700	23,500	24,650	20,700	41,800	73,300	68,200
10	73,200	71,500	69,600	63,300	48,100	33,800	20,500	20,500	21,800	18,400	27,900	64,400	53,500

Alternative 3E

This alternative is similar to Alternative 3B except that the isolated facility has a capacity of 15,000 cfs instead of 5,000 cfs, and it does not include the Old River enlargement and barrier.

Impact 3-3 (Beneficial). *Lowered flood flows during relatively small floods.* Withdrawing 15,000 cfs from the Sacramento River could have the effect of lowering flood flows for small floods (10-year and smaller), but would not have a significant effect on large floods (100-year and larger). If the 100-year flood flows downstream of Hood (or Freeport) could be reduced by 15,000 cfs they would be equivalent to about a 20-year event. This would still be large enough to cause considerable flooding under the No-Action Alternative.

Alternative 3F

Storage. This alternative would provide for upstream surface water storage in the Sacramento and San Joaquin River basins, off-aqueduct storage south of the Delta, and additional groundwater storage. The impacts of these options were discussed under Alternative 3A. This option also provides for "Chain of Lakes" storage in the Delta. This would consist of a connected chain of up to eight lakes created by flooding Delta islands. Water would be conveyed between islands with siphons and pumps. The islands include Tyler, Bouldin, Venice, Mandeville, Bacon, Woodward and Victoria.

There is enough storage available in these islands to reduce flood flows in the Delta, however, the storage would be equally divided among urban, environmental and agricultural uses. None of it would be dedicated to flood control. In addition, all of storage associated with the "Chain of Lakes" is located off-line and as such would have limited utility for flood storage. Its ability to reduce peak flows would be limited by the ability of the pumps and intakes to remove water from adjacent channels as well as the storage available during flood events.

Conveyance Facilities. A 10,000 cfs intake at the Delta Cross Channel would be constructed plus 5,000 cfs from distributed pumps in the Delta. Additional conveyance options include the North Channel Modifications described in Alternative 2A and the operable barrier at the head of Old River. The North Channel Modifications and operable barrier impacts were discussed earlier. Assuming the 10,000 cfs intake could operate at full capacity during a large storm event, it could significantly reduce the flood flows of smaller storm events (e.g., 20-year storms and smaller), but would not reduce the flood flows significantly for large flows (e.g., 100 year storm events).

Alternative 3G

Storage. The new storage is the same as that discussed in Alternative 2B.

Conveyance Facilities. Conveyance in this option includes the north and south Delta channel modifications as described in Alternative 2B. Impacts of these options were described under Alternative 3A. This alternative also includes a 5,000 cfs isolated facility located west of the Delta. Water would be removed from the Sacramento River near the Port of Sacramento. Five thousand cubic feet per second is less than 10% of the storm flows in the Sacramento below Sacramento (Table 4). Therefore, removing only 5,000 cfs from the Sacramento River would, therefore, not significantly reduce flood flows in the Delta.

Alternative 3H

Storage. This alternative has the same options that were discussed in Alternative 2B.

Conveyance Facilities. This alternative has the same options that were discussed in Alternative 2E plus the 5000 cfs isolated facility discussed in Alternative 3A.

Alternative 3I

This alternative is a combination of alternatives 2C and 3E.

Storage. The storage options are similar to those described in previous alternatives (e.g., alternative 2B) and their impacts on flood control are discussed there.

Conveyance Facilities. The conveyance facilities for this option are a combination of those in Alternatives 2C and 3E. Flood control benefits of these options are described under those alternatives.

The open channel isolated facility could increase flooding east of the facility if a levee on the Mokelumne River was to break and the facility was constructed in a way that impeded stormwater and flood flow runoff and drainage. These impacts can be mitigated with proper design.

5.2.2 Bay Region

The Bay Region includes the Suisun Marsh and North San Francisco Bay Ecological Zone. The ERPP component of the Common Program includes several actions that would modify flows within the Bay Region, including the establishment of shallow water habitat, open water habitat, tidal sloughs, seasonal wetlands and riparian/shaded riverine habitat. None of the other components of the Common Program include actions related to flooding in the Bay Region, neither do any of the alternatives. In addition, there are presently no flooding problems in this region. The proposed modifications to flows in the ERPP are minor relative to the volume of water in the Bay region.

There would be no significant impacts to flood control in the Bay Region.

5.2.3 Sacramento River Region

5.2.3.1 Alternative 1

Common Program Impacts

The only Common Program containing elements related to flood control in the Sacramento River Region is the ERPP. Table A-2 in the Appendix (Section 7.0) lists those Resource Elements related to flood control and the associated actions. Most are associated with improving fish migration and restoring streams to more natural conditions. The action items associated with flood management can be divided into four actions:

1. Restore or preserve the 50- to 100-year floodplain on tributaries to the Sacramento.
2. Remove diversions and other obstructions to fish migrations.
3. Vegetate or revegetate stream banks to increase riverine habitat.
4. Improve floodwater detention in Colusa and Yolo Basins.

Restoring the 50- and 100-year floodplains would provide positive flood control benefits. The amount of benefit would depend on the existing flood conveyance of the stream channels chosen for improvements. The protection of existing floodplains would provide no benefits over existing conditions, but to the extent that future development is prevented in the floodplain, flood benefits would be positive relative to the No Action alternative.

Impact 1-11 (Adverse). *Increased level of flooding downstream of removed diversions.* Removing diversion structures and other obstructions to flow in the Sacramento River tributaries could increase the level of flooding downstream of these diversions. The level of increase would depend upon which diversions and obstructions are removed and the total number of obstructions removed. The relative increase in flooding would probably be small for large flood events (e.g., 100-year) and relatively larger for small flood events (e.g., 10-year). The change in flood levels would depend upon how much attenuation of flood flows the existing structures provide.

Mitigation Strategy. This impact could be mitigated by widening streams downstream of the structure to increase conveyance capacity.

Impact 1-12 (Adverse). *Raised flood levels due to vegetation along stream banks.* Vegetating stream banks could increase stages along streams due to increases in the roughness of the stream channel. On wide channels, the increase in roughness of the stream banks would probably have only a minor impact on flood stage. On small streams, the increase could be significant.

Mitigation Strategy. This impact could be mitigated with proper design that incorporates flood control criteria. For example, by increasing the width of vegetated sections to maintain conveyance capacity.

Storage and Conveyance Impacts

Alternative 1A

No new storage or conveyance facilities are included in this alternative.

Alternative 1B

No new storage or conveyance facilities are included in this alternative.

Alternative 1C

Storage. New storage facilities that could be potentially built in the Sacramento River Valley include 3 million acre-feet of surface storage and 500,000 acre-feet of groundwater storage. None of the storage would be devoted to flood control. The 3 million acre-feet of additional surface storage could provide localized flood control if it is incidentally available when a large storm event occurs. For example, if an additional 500,000 acre-feet or more of storage had been available in 1986 on the Feather or

Yuba Rivers some flooding could have been avoided (Table 3). However, since the additional storage is not allocated to flood control it would have to be considered unreliable as a flood control measure.

Conveyance Facilities. No new conveyance facilities are proposed under Alternative 1C.

5.2.3.2 Alternative 2

Common Program Impacts

The impacts of the Common Program would be similar to those described under Alternative 1 (Section 5.2.3.1).

Storage and Conveyance Facilities Impacts

Storage. Alternatives 2B and E consist of the same storage elements as Alternative 1C.

Conveyance Facilities. No new conveyance facilities are proposed in the Sacramento River Valley in Alternative 2.

5.2.3.3 Alternative 3

Storage. Same storage as Alternative 1C.

Conveyance Facilities. No new conveyance facilities are proposed in the Sacramento river Valley under Alternative 3.

5.2.4 San Joaquin River Region

5.2.4.1 Alternative 1

Common Program Impacts

The only Common Program element related to flood control in the San Joaquin River Region is the ERPP. Table A-3 in the Appendix (Section 7.0) lists those Resource Elements related to flood control and the associated actions. Most are associated with increasing or protecting riparian habitat or reestablishing floodplains.

Impact 1-13 (Beneficial). *Reduced flood stages due to restoration of floodplains along the San Joaquin River.* Restoring the floodplains along the San Joaquin River south of Vernalis would provide positive flood control benefits. Presently, the probability of levee failures is high during large storm events in the San Joaquin River Valley. By creating a large floodplain flood stages would be lowered, thereby reducing the pressure on downstream levees. The level of additional protection provided by the floodplain would depend upon the size of the floodplain and its location relative to the most critical levees.

Impact 1-14 (Adverse). *Raised flood levels as a result of allowing riparian vegetation growth.* Reestablishing riparian habitat or preventing the removal of riparian vegetation would result in increasing the roughness of the stream channel and could increase stages. On wide channels, the increase in roughness of the stream banks would probably have only a minor impact on flood stage. On small streams the increase could be significant.

Mitigation Strategy. This impact could be mitigated through proper designs that incorporate flood control criteria, such as widening vegetated sections to maintain conveyance capacity.

Storage and Conveyance Impacts

Storage. New storage facilities that could be potentially built in the San Joaquin River Valley include 1 million acre-feet of off-aqueduct surface storage and 500,000 acre-feet of groundwater storage. None of the storage would be devoted to flood control. Also, since the 1 million acre-feet of additional surface water storage would be located off-line, it would have limited ability to reduce peak storm flows.

Conveyance Facilities. No new conveyance facilities are proposed under Alternative 1.

5.2.4.2 Alternative 2

Common Program Impacts

The impacts of the Common Program are similar to those identified under Alternative 1 (Section 5.2.4.1).

Storage and Conveyance Facilities Impacts

There are five variations of Alternative 2 (Alternative 2A-E).

Storage. Alternative 2B contains 500,000 acre-feet of surface water storage in the San Joaquin Valley, 2 million acre-feet of off-aqueduct surface storage and 500,000 acre-feet of groundwater storage. None of the storage would be devoted to flood control. Also, the 2 million acre-feet of off-aqueduct additional surface storage would have limited ability to reduce peak storm flows since it does not receive storm runoff. Only the 500,000 acre-feet of surface storage could potentially impact flood flows. See the discussion in Section 5.2.1.2, Alternative 2 for the Delta.

Conveyance Facilities. No new conveyance facilities are proposed in the San Joaquin River Valley under Alternative 2.

5.2.4.3 Alternative 3

Common Program Impacts

The impacts of the Common Program would be similar to those described under Alternative 1 (Section 5.2.4.1).

Storage and Conveyance Facilities Impacts

Storage. Same storage as Alternative 2B.

Conveyance Facilities. No new conveyance facilities are proposed in the San Joaquin River Valley in Alternative 3.

5.2.5 SWP and CVP Service Areas Outside of the Central Valley

There are no actions related to the SWP or CVP services areas outside of the Central Valley that would impact flood management.

Significant Impacts/Mitigations - There are no significant impacts to flood control.

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5.3 Summary of Impacts

Table 5 summarizes the impacts of the alternatives according to parameter or resource.

Alternative 1

Flood stages will generally be similar to existing levels under alternative 1. Localized South Delta stage increases could result during the nonflood season due to minor flow impediments, but would not significantly affect the flood control system. Seepage will continue as an ongoing process, especially in the Delta Region (e.g., near Victoria Island and Byron Tract), but is considered as a less than significant impact on flood control resources. Inspection, Maintenance, repair, and emergency response capabilities would be similar to existing conditions, and subsidence would continue to occur where peat soils degrade, usually because of agricultural tillage. Levee settlement on soft foundation materials, wind-generated wave erosion, levee scour and stability would be similar to existing conditions. Less than significant increases in sedimentation could result from generally reduced velocities in shallow flooded areas established for habitat. Channel capacities would be similar to existing conditions, with less than significant decreases possible where sedimentation accompanies slower flow velocities.

Alternative 2 and 3

Flood stages would decrease in the North Delta area. Localized South Delta stage increases could result during the nonflood season due to minor flow impediments, but would not significantly affect the flood control system. Seepage would continue as an ongoing process, especially in the Delta Region (e.g., near Victoria Island and Byron Tract), but is considered as a less than significant impact on flood control resources. Increases in shallow flooding for habitat would increase the possibility that seepage could be an impact when comparing subalternatives. Inspection, maintenance, and repair capabilities would be easier than under existing conditions, because setback levees would allow greater access planned as part of construction. Subsidence would continue to occur where peat soils degrade, usually because of agricultural tillage. Emergency response capabilities would be slightly improved with the construction of setback levees and improved access, but would not be significantly benefitted until the Delta Levee System Integrity Program is implemented. Increased settlement is possible for levees that could be set back as far as 500 feet from the current levee locations, but is not considered a significant impact so long as it is monitored over the long-term. Wind-generated wave erosion would increase near setback levees and on flooded islands, as greater expanses of water would be subject to wind-fetch. Levee scour would be reduced at locations where channel widening is planned, with less than significant adverse increases in sedimentation associated with slower flow velocities. Channel widenings would improve capacities.

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Table 5
Summary of Flood Control System Impacts

Parameter Constituent	Existing Conditions	No Action	Alt 1			Alt 2					Alt 3								
			1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
STAGE				Local south Delta stage increases.	Incidental flood storage benefits.	Local south Delta stage increases.	Incidental flood storage benefits.		Reduced stages due to isolated intakes.	Incidental flood storage benefits.	Potentially significant increased stage on east side tributaries due to isolated facility.	Potentially significant increased stage on east side tributaries due to isolated facility.			Potentially significant increased stage on east side tributaries due to isolated facility.			Potentially significant increased stage on east side tributaries due to isolated facility.	Reduced stages due to isolated intakes.
					Local south Delta stage increases.	Decreased stages in the north Delta	Decreased stages in the north Delta		Incidental flood storage benefits.	Decreased north Delta stages along setback levees and floodways.	Incidental flood storage benefits.	Incidental flood storage benefits.			Incidental flood storage benefits.			Incidental flood storage benefits.	Incidental flood storage benefits.
							Local south Delta stage increases.		Decreased north Delta stages along setback levees and floodways.		Local south Delta stage increases.	Local south Delta stage increases.			Reduced flood flows due to 15,000 cfs isolated facility.			Decreased north Delta stages along setback levees and floodways.	
SEEPAGE			Similar to existing	Less than significant adjacent to south Delta flow control barriers.	Less than significant adjacent to south Delta flow control barriers.	Less than significant adjacent to south Delta flow control barriers and flooded islands.	Less than significant adjacent to south Delta flow control barriers and flooded islands.		Increased seepage beyond Alt 2b.	Increased seepage beyond Alt 2d.	Potential seepage from isolated transfer facility canal.	Potential seepage from isolated transfer facility canal.			Potential seepage from isolated transfer facility canal.			Potential seepage from isolated transfer facility canal.	Increased seepage near Holland Tract.
			Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.		Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.			Increased as a result of deep-rooted trees and shrubs penetrating levees.			Increased as a result of deep-rooted trees and shrubs penetrating levees.	Increased as a result of deep-rooted trees and shrubs penetrating levees.
INSPECTION						Easier to inspect setback levees.	Easier to inspect setback levees.		Easier to inspect setback levees.	Easier to inspect setback levees.	Easier to inspect setback levees.	Easier to inspect setback levees.			Easier to inspect setback levees.			Easier to inspect setback levees.	Easier to inspect setback levees.
MAINTENANCE			Reduced capability due to vegetation.	Reduced capability due to vegetation.	Reduced capability due to vegetation.	Easier to maintain setback levees, but more costly.	Easier to maintain setback levees, but more costly.		Easier to maintain setback levees, but more costly.	Easier to maintain setback levees, but more costly.	Easier to maintain setback levees, but more costly.	Easier to maintain setback levees, but more costly.			Easier to maintain setback levees, but more costly.			Easier to maintain setback levees, but more costly.	Easier to maintain setback levees, but more costly.

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Table 5
Summary of Flood Control System Impacts

Parameter Constituent	Existing Conditions	No Action	Alt 1			Alt 2					Alt 3								
			1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
REPAIR			Reduced capability due to vegetation.	Reduced capability due to vegetation.	Reduced capability due to vegetation.	Easier to repair setback levees.	Easier to repair setback levees.		Easier to repair setback levees.	Easier to repair setback levees.	Easier to repair setback levees.	Easier to repair setback levees.			Easier to repair setback levees.			Easier to repair setback levees.	Easier to repair setback levees.
SUBSIDENCE			Similar to existing.	Similar to existing.	Similar to existing.	Similar to existing.	Similar to existing.		Similar to existing.	Similar to existing.	Similar to existing.	Similar to existing.			Similar to existing.			Similar to existing.	Similar to existing.
SETTLEMENT			Similar to existing.	Similar to existing.	Similar to existing.	Increased settlement for setback levee.	Increased settlement for setback levee.		Increased settlement for setback levee.	Increased settlement for setback levee.	Increased settlement for setback levee.	Increased settlement for setback levee.			Increased settlement for setback levee.			Increased settlement for setback levee.	Increased settlement for setback levee.
WIND-GENERATED WAVE EROSION			Less than significant due to increased vegetative protection.	Less than significant due to increased vegetative protection.	Less than significant due to increased vegetative protection.	Less than significant for setback levees. Potential adverse impact on flooded islands.	Less than significant for setback levees. Potential adverse impact on flooded islands.		Less than significant for setback levees. Potential adverse impact on flooded islands.	Less than significant for setback levees. Potential adverse impact on flooded islands.	Less than significant for setback levees. Potential adverse impact on flooded islands.	Less than significant for setback levees. Potential adverse impact on flooded islands.			Less than significant for setback levees. Potential adverse impact on flooded islands.			Less than significant for setback levees. Potential adverse impact on flooded islands.	Less than significant for setback levees. Potential adverse impact on flooded islands.
SCOUR			Similar to existing.	Similar to existing.	Similar to existing.	Reduced at widened locations.	Reduced at widened locations.		Reduced at widened locations.	Reduced at widened locations.	Reduced at widened locations.	Reduced at widened locations.			Reduced at widened locations.			Reduced at widened locations.	Reduced at widened locations.
LEVEE STABILITY			Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.		Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.			Potentially reduced as a result of stage and seepage effects noted above.			Potentially reduced as a result of stage and seepage effects noted above.	Potentially reduced as a result of stage and seepage effects noted above.
EMERGENCY RESPONSE			Similar to existing.	Similar to existing.	Similar to existing.	Similar to existing.	Similar to existing.		Similar to existing.	Similar to existing.	Similar to existing.	Similar to existing.			Similar to existing.			Similar to existing.	Similar to existing.
CHANNEL CAPACITY			Improved capacity at widened locations. Reduced conveyance capacity due gate structures.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures. Increased capacity due to intake.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures. Increased capacity due to intake.		Improved capacity at widened locations. Reduced conveyance capacity due gate structures. Increased capacity due to intake.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures. Increased capacity due to intake.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures.			Improved capacity at widened locations. Reduced conveyance capacity due gate structures.			Improved capacity at widened locations. Reduced conveyance capacity due gate structures.	Improved capacity at widened locations. Reduced conveyance capacity due gate structures.

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7.0 APPENDIX

Table A-1 was used to screen resource elements of the Ecosystem Restoration Program and determine which elements would impact the flood control system. The table summarizes the resource element and flood related actions, and idenfies whether the action would impact flood management. For more specific information regarding the actions listed, refer to the Phase II Alternatives Descriptions Report (CALFED 1997).

Table A-1
Delta Region Resource Elements and Impacts of Actions on Flood Management

Resource Element	Flood Related Actions	Significant Impact on Flood Management
Stream Flows	Provide pulse flows	no
Delta Channel Hydraulics	Reduce flows in selected channels	yes
	Construct network of channels and reduce constrictions in the Yolo Bypass	no
Water Temperature	None	no
Floodplain Inundation and Sediment Retention	Convert selected leveed lands to tidal marsh/slough complexes, construct set-back levees, connect dead end sloughs, construct overflow basins.	yes
Food Web	None	no
Levees and Bank Protection	Modify levee and berm vegetation management practices on water side of levee	yes
Dredging	None	no
Exotic Species	None	no
Predators	None	no
Unscreened and Poorly Screened Diversions	None	no
Contaminants	None	no
Boat Wake Erosion	Reduce boat traffic in selected channels	no
Illegal and Legal Harvest of Fish and Wildlife	None	no
Shallow Water Habitat	Flood selected islands, primarily with land elevations between -5 and -9 feet	Maybe. Volume provided by additional storage too small (10-70,000 acre-feet) relative to size of Delta (over 700,000 acres) and duration of flood events (several days). However, could provide localized flood control benefits.
Non-tidal Perennial Aquatic Habitat	Acquire and develop deeper open-water areas within restored saline emergent wetland habitats	no (Too small an area)

C-002305

C-002305

Resource Element	Flood Related Actions	Significant Impact on Flood Management
Tidal Slough Habitat	Restore tidal slough habitat	no (It is assumed the new sloughs would not contribute significantly to conveyance in Delta)
Seasonal Wetland Habitat	Restore and manage additional acreage	no (Largest restoration would be in designated floodplain expansion areas)
Riparian Scrub Habitat	Obtain conservation easements or purchase from willing sellers land needed to restore riparian habitat	yes
Riparian Woodlands	Purchase riparian wookland property or easements	no
Tidal Emergent Wetland Habitat	Develop tidal wetlands	yes
Non-tidal Emergent Wetland Habitat	Restore non-tidal emergent wetland habitat	no (However, could have local flood control benefits)
Mid-channel Islands	Protect and improve existing channels in the Delta	no

Table A-2 summarizes the actions in the ERPP that could affect the flood control system in the Sacramento River Region. This table is based upon the table contained in the Phase II Alternatives Descriptions Report (CALFED 1997).

Table A-2
Sacramento Region Resource Elements That May Impact Flood Management

Resource Element	Flood Related Actions
Shaded Riverine Aquatic Habitat (SR)	Vegetate baren riprapped banks and construct setback levees to provide wider floodplains
Diversion Dams-Fish Passage and Predators (SR)	Make physical changes to structures in the Sacramento River, such as bridge abutments, diversion dams and water intakes
Stream Meander Belts (NSV)	Restore the 50- to 100-year floodplain of Cedar Creek
Dams, Reservoirs, and Other Human-Made Structures (NSV)	Remove diversions from South Cow Creek, Old Cow Creek, North Cow Creek, and Clover Creek that are barriers to migrating salmon.
Stream Meander Belts (CC)	Preserve or restore the 50- to 100-year floodplain. Evaluate the construction of setback levees to allow channel meander in areas presently confined by levees.
Dams, Reservoirs and Other Human-Made Structures	Reconstruct facilities and structures that impair fish passage.
Floodwater and Sediment Detention and Retention (CB)	Improve the sediment deposition capacity of the Colusa Basin.
Dams, Reservoirs, and Other Human-Made Structures (CB)	Reduce hindrances to fish passage and reduce the use of seasonal barriers.
Stream Meander Belts (BB)	Preserve or restore the 50- to 100-year floodplains along the lower reaches of stream. Evaluate the construction of setback levees to allow channel meander in areas presently confined by levees

C-002306

C-002306

Resource Element	Flood Related Actions
Dams, Reservoirs and Other Human-Made Structures (BB)	Evaluate the feasibility of removing diversion dams on Butte Creek.
Dams, Reservoirs and Other Human-Made Structures (FRS)	Remove dams on Yuba River. Remove or modify culvert crossings on Bear River.
Natural Stream Channel Process (ARB)	Maintain floodplain along the lower American River. Develop a floodplain management program.
Stream Channel Configuration (YB)	Evaluate the feasibility of modifying cross-sections and channel configurations in Cache Creek and Putah Creek. Reconfigure the Yolo Bypass to restore its natural configuration with slough connections to Cache and Putah Creeks.
Floodwater and Sediment Detention and Retention (YB)	Evaluate the feasibility of reoperating and modifying the Yolo Basin to increase its capacity for floodwater detention and sediment retention.
SR = Sacramento River Ecological Zone NSV = North Sacramento Valley Ecological Zone CC = Cottonwood Creek Ecological Zone CB = Colusa Basin Ecological Zone BB = Butte Basin FRS = Feather River/Sutter Basin Ecological Zone ARB = American River Basin Ecological Zone YB = Yolo Basin	

Table A-3 summarizes the actions in the ERPP that could affect the flood control system in the San Joaquin River Region. This table is based upon the table contained in the Phase II Alternatives Descriptions Report (CALFED 1997).

Table A-3
San Joaquin River Region Resource Elements That May Impact Flood Management

Resource Element	Flood Related Actions
Shaded Riverine Aquatic Habitat (EDT)	Restore 15 stream miles of self-sustaining diverse riparian community along the Mokelumne River.
Stream Meander Migration (SJR)	Restore the defined floodplain; reestablish stream meander zone on the San Joaquin River between Vernalis and the mouth the Merced River.
Levees, Bridges, and Bank Protection (SJR)	Set back 10 miles of levees along the San Joaquin River between the Merced River and Vernalis.
Shaded Riverine Aquatic Habitat (SJR)	Restore 50 stream miles of self-sustaining diverse riparian community.
Shaded Riverine Aquatic and Riparian Habitat (ESJB)	Restore 15 stream miles of self-sustaining diverse riparian community along each river.
EDT = Eastside Delta Tributaries Ecological Zone SJR = San Joaquin River Ecological Zone ESJB = East San Joaquin Basin Ecological Zone	